

COURSE SCHEDULE

DAY 1

8:30 – 10:00am	INTRODUCTION AND WELCOME KM64-001 QUALIFICATION PROGRAM FOR TECHNICIANS SPECIFICATIONS Section 713: Permanent Pavement Paints Section 842: Materials Requirement for Paint Section 714: Durable Striping Section 717: Intersection Markings CONTRACTOR STRIPING SPECIFICATIONS
10:00 – 10:15am	BREAK
10:15 – 10:45am	MATERIALS HANDLING Kentucky Method 201: LTL Inspection of Intersection Markings Kentucky Method 202: LTL Inspection of Pavement Markings Kentucky Method 203: Mobile Inspection of Pavement Markings
10:45 – 11:30am	LTL 2000 DOWNLAD INSTRUCTIONS INSPECTION SPREADSHEETS
11:30 – 1:30pm	LUNCH
1:00 – 4:00pm	LTL 2000 Overview Hands on Demonstration

DAY 2

8:30 - 9:00am	REVIEW
9:00 – UNTIL	WRITTEN AND PRACTICAL EXAM

***Between the written and practical exam, participants will have an opportunity to take a break and practice for the second part of the exam.**

QUALIFIED
PAVEMENT MARKING
TECHNICIAN
TRAINING

TABLE OF CONTENTS

1. SPECIFICATIONS
2. MATERIALS HANDLING
KENTUCKY METHODS
3. LTL 2000 DOWNLOAD INSTRUCTIONS
INSPECTION SPREADSHEETS
4. LTL 2000 OVERVIEW
5. LTL 2000 MANUAL
QUICK REFERENCE SHEETS

INTRODUCTION & WELCOME

1. Visitor Check-In & Out
2. Restrooms & Concessions

REASON FOR THE COURSE

KM 64-001

According to the Federal Highway Administration Policy all acceptance sampling and testing must be performed by what they refer to as “Qualified Personnel.” In response to the federal policy, the state Qualification Program for Technicians was developed.

Kentucky Method 64-001-02 covers qualification and disqualification procedures for inspectors. This method states that to qualify you must attend training and pass a written test and practical. On the other hand, there are reasons provided for disqualification:

1. Failure to pass requalification class
2. Found to be guilty of falsifying test results, records, and/or reports.
3. Improper performance of tests

OVERVIEW OF THE COURSE

DAY 1

We will begin by discussing **Kentucky Standard Specifications 713, 714 and 717**. Your manuals also include **Specification 842**. Section 2 of your manuals covers material handling and **Kentucky Methods 201, 202 and 203**. John Mark will finish the day by providing us with an **overview of the LTL2000** and then we will have **hands-on practice with the LTL2000**.

DAY 2

At the start of the day we will have a brief **question and answer session** followed by an open book exam. After the **written exam**, there is a **practical test**. For the practical the manuals are not allowed. Also, the practical will include written questions.

NO RETEST

30-40% FAILURE RATE

1. Participants do not know where to find the answer in the manual because they did not a) follow along during the class and b) look over their manuals the night before the test.
2. Participants do not spend enough time practicing with the LTL2000.
STAY UNTIL YOU ARE COMFORTABLE!

Kentucky Method 64-001-05
Revised 01/28/05
Supersedes 64-001-02
Dated 12/16/02

KENTUCKY TRANSPORTATION CABINET
QUALIFICATION PROGRAM FOR TECHNICIANS

1. SCOPE:
 - 1.1. According to the Federal Highway Administration Policy Guide, Subchapter G, Part 637, Subpart B – Quality Assurance Procedures for Construction, all acceptance sampling and testing must be performed by “qualified personnel”.
 - 1.2. The Kentucky Department of Highways has established a Quality Assurance (QA) program to ensure that materials and workmanship incorporated into any highway construction project are in reasonable conformity with the requirements of the approved plans and specifications, including any approved changes. This QA program allows for the use of validated, contractor-performed, quality control (QC) test results as part of an acceptance decision. It also allows for the use of test results obtained by commercial laboratories in the Independent Assurance (IA) program as well as in acceptance decisions.
2. REFERENCED DOCUMENTS: Kentucky Department of Highways Quality Assurance Program for Materials Testing and Acceptance
3. QUALIFICATION PROGRAM STEERING COMMITTEE (QPSC): The Qualification Program is overseen by a Steering Committee consisting of the following representatives:
 - State Highway Engineer
 - Deputy State Highway Engineer for Project Delivery
 - Director, Division of Construction
 - Director, Division of Materials
 - Director, Division of Employee Development
 - Division of Materials Qualification Coordinator
 - Representative, Federal Highway Administration
 - Representative, Kentucky Ready Mix Concrete Association (KRMCA)
 - Representative, Kentucky Association of Highway Contractors (KAHC)
 - Representative, Kentucky Crushed Stone Association (KCSA)

Representative, Plantmix Asphalt Industry of Kentucky (PAIKY)

4. QUALIFICATION TYPES:

4.1. Aggregate:

4.1.1. Aggregate Sampling Technician

4.1.2. Qualified Aggregate Technician

4.2. Hot-Mix Asphalt:

4.2.1. Superpave Plant Technologist

4.2.2. Superpave Mix Design Technologist

4.2.3. Asphalt Field Technician

4.3. Coatings Inspection:

4.3.1. Bridge Coating Inspector

4.3.2. Shop Coatings Inspector

4.3.3. Pavement Markings Inspector

4.4. Concrete:

4.4.1. American Concrete Institute (ACI) Level I

4.4.2. Kentucky Ready-Mixed Concrete Association Level II

4.5. Soils:

4.5.1 Grading Technician Level I

4.5.2 Grading Technician Level II

5. QUALIFICATION POLICIES:

5.1. To qualify, an individual must successfully perform the specific tests and necessary calculations required for each qualification type in the presence of an authorized evaluator. Successful performance is defined as demonstrating the ability to properly perform the key elements for each test method. If the individual fails to demonstrate the ability to perform a test, the individual may be allowed one retest per test method at the evaluator's discretion.

- 5.2. In addition to successful performance of a test method, the individual must also pass a written examination administered by an authorized evaluator. An individual failing the written examination may request a retest. The individual may be allowed one retest at the evaluator's discretion. The retest must be requested, scheduled and administered within 30 days of the notification of failure. Failure to pass the second written examination shall be considered as failing the entire qualification.
 - 5.3. Qualification of an individual is valid for not more than five years. After that time, the individual must qualify again. Under the requirements of the QA program, interim evaluations will be permitted when appropriately justified.
 - 5.4. Test questions and other examination data used to administer this qualification program are subject to reuse and are considered confidential and exempt from public records inspection.
6. EXAMINATION METHODS AND POLICIES:
- 6.1. A standard set of examinations for each qualification will be used statewide. The examinations will be developed by a committee composed of personnel from some or all of the following: Division of Materials, Division of Construction, and appropriate industry representatives.
 - 6.2. In addition, the individual may be required to participate in proficiency sample testing administered by the qualification authority to validate the qualification. The result of the proficiency samples will be evaluated for compliance with acceptable tolerance limits. If the comparison of test results does not comply with the tolerances, an engineering review of the test procedures and equipment shall be performed immediately to determine the source of the discrepancy. Corrective actions must be identified, and incorporated as appropriate, prior to the individual performing additional testing on that test method.
7. DISQUALIFICATION PROCEDURES: A qualified individual can be disqualified for any of the following reasons:
- 7.1. Failure to pass requalification requirements and/or provide payment of fees, initial or requalification.
 - 7.2. Found to be guilty of falsifying test results, records, and/or reports. Allegations of falsifying test results and/or reports will be made to the QPSC in writing. The allegations will contain the name, address, and signature of the individual(s) making the allegation. The allegations will be investigated by the QPSC. The accused and the individual(s) making the allegation will be given the opportunity to appear before the QPSC. All involved parties will be notified in writing of the findings by the QPSC. Any warranted actions will be imposed according to the guidance contained herein. Decisions regarding allegations of falsifying test results and/or reports may be appealed in writing to the QPSC which will consider such written appeals and take such action considered appropriate.
 - 7.2.1. First offense would result in a 12-month revocation of qualification status in all

qualification types. Prior to reinstatement, the individual shall again successfully complete qualification classes.

7.2.2. Second offense would result in a permanent loss of qualification status in all qualification types.

7.3. Improper performance of tests, failure to perform tests, or finding an individual incapable of performing tests required by the contract documents and documented by a qualified technician - documentation ("Violation Report" form, copy attached) to include the date(s), time(s), location(s), occurrence(s) of non-conformance, and signature of the qualified technician reporting the incident. The following punitive actions will occur after the QPSC receives two Violation Reports on an individual technician.

7.3.1. First offense would result in a warning from the QPSC.

7.3.2. Second offense would result in a five-day revocation of qualification status and three-month probation.

7.3.3. Third offense would result in a revocation of qualification status. When a qualification is revoked, the individual may obtain that qualification again after successfully completing qualification classes and a six-month probation period.

APPROVED _____
Director
DIVISION OF MATERIALS

DATE 01/28/05 _____

Kentucky Method 64-001-05
Revised 01/28/05
Supersedes 64-001-02
Dated 12/16/02

km00105.doc

KENTUCKY QUALIFICATION PROGRAM FOR TECHNICIANS REPORT OF VIOLATION

The undersigned Kentucky Qualified Technician has witnessed and documented violation(s) of the Technician Qualification Program. These violations are outlined in Section 7 of KM 64-001, Kentucky Transportation Cabinet Qualification Program for Technicians. The qualified technician noted in violation is:

Name

Certification No.

Date(s) of Violation

Time(s) of Violation

Location(s) of Violation

Description of the violation (Attach additional sheets if necessary):

Qualified Technician

Inspector ID Number

Date

Signature

SPECIFICATIONS

Pavement Marking Inspector Training

Brandi R. Body David Rice
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Division of Materials
2006

Standard Specifications for Striping

ØSection 713

ØSection 714

ØSection 717

Section 713

**PERMANENT PAVEMENT MARKING
PAINTS**

APPLIED ON RESURFACING PROJECTS



MATERIALS REQUIREMENT

- Ø VALID PAINT SAMPLES MEET THE REQUIREMENT OF SECTION 842
- Ø GLASS BEADS EVALUATED AS PART OF THE LINE

VALID PAINT SAMPLES

Ø LINED CAN

Ø CERTIFICATION

MINIMUM APPLICATION RATES

4" Line – 16.5 gal/mile of Paint

6" Line – 24.8 gal/mile of Paint

6 Pounds/gallon of Glass Beads

PROVING PERIOD SECTION

- ⊗ Proving period – facility open to traffic
- ⊗ Readings to be taken 30-60 days after proving period begins

- ⊗ Minimum Retroreflectivity Requirements
 - | White 175 mcd/m²/lux
 - | Yellow 150 mcd/m²/lux

PASS/FAIL DECISIONS

- ⊗ BASED ON KM 202
 - | 80% of the readings in the segments must pass

- ⊗ ACCEPTANCE WITH DEDUCTION
 - | Sliding scale for acceptance with deduction

ACCEPTANCE PAY SCHEDULE

White	Yellow
156 to 174 mcd – 50%	126 to 149 mcd – 50%
138 to 155 mcd – 25%	103 to 125 mcd – 25%
120 to 137 mcd – 0%	80 to 102 mcd – 0%
<120 mcd - unacceptable	<80 mcd - unacceptable

SECTION 714

Durable Striping (Tape, Thermoplastic)



SAMPLING THERMOPLASTIC

Ø SMALL QUANTITIES

- List of Approved Materials
- Manufacturer's Certification

Ø QUANTITIES > 250 POUNDS

- List of Approved Materials
- Manufacturer's Certification
- Provide one unopened bag of thermoplastic per batch per color of material delivered to the project

MINIMUM APPLICATION RATES

Ø 90 mil Line (Thermoplastic)

EQUIPMENT REQUIREMENTS

1. DO NOT use a spray or ribbon gun applicator
2. Extrusion die deposits and shapes lines
3. Equipment must be capable of maintaining continuous and uniform heating between 400 and 440°F

EQUIPMENT CONTINUED...

4. Kettle capable of continuous agitation
5. Motorized and capable of applying line at a rate of 3 mph
6. Cut off device to provide clean, square ends
7. Automated bead dispenser

PERFORM BOND CHECKS

60 to 120 seconds after application, cut a six inch strip of thermoplastic and pull up. Bonding has successfully occurred if asphalt clings to the removed strip.

RESTRICTIONS

Ø DO NOT APPLY IF:

- ▮ Air and Pavement Temperatures < 50°F



PROVING PERIOD

- Ø **180 DAYS**
- Ø **Minimum Retroreflectivity Requirements**
 - White 300 mcd/m²/lux
 - Yellow 175 mcd/m²/lux
- Ø **Readings to be taken 150 - 210 days after start of proving period**
 - KM 202 – Portable Readings (LTL 2000)
 - KM 203 – Mobile Readings (Mobile Van)

PAYMENT

- Ø **PAY SCHEDULE**
 - Table contained in Section 714
- Ø **FAILURE**
 - Repair or remove and replace defective lengths of material

SECTION 717

Intersection Markings

Preformed

- List of Approved Materials
- 125 mil minimum thickness

Extruded

90 mil Line



EQUIPMENT REQUIREMENTS

- Ø DO NOT use spray or ribbon gun applicators
- Ø Extrusion die deposits and shapes lines
- Ø Maintains uniform heating between 400 and 440°F
- Ø Kettle is capable of continuous agitation
- Ø Cutoff device provides clean, square ends
- Ø Automated bead dispenser

PERFORM BOND CHECKS

Ø DO NOT APPLY IF

- ┆ Air and pavement temperatures are <50°F



PROVING PERIOD

- Ø 180 Days
- Ø Minimum Retroreflectivity Requirements
 - White 300 mcd/m²/lux
 - Yellow 175 mcd/m²/lux
- Ø Readings taken 30-60 days after start of Proving Period
 - KM201 – Readings for Intersection markings (LTL 2000)

PAYMENT

- Ø Pay schedule for each marking –
Bid Item Quantity
- Ø Failure
 - Repair or remove and replace defective markings

Contract Striping For WATERBORNE TRAFFIC PAINT

*Districts Participating in
Contract Striping*

D1 – Paducah	D7 – Lexington
D2 – Madisonville	D8 – Somerset
D3 – Bowling Green	D9 – Flemingsburg
D4 – Elizabethtown	D10 – Jackson
D5 – Louisville	D11- Manchester
D6 - Covington	D12 - Pikeville

BASIC SPECIFICATIONS

Minimum Application Rates
(ONLY A GUIDE)

- | 4" Line – 16.5 gal/mile
- | 6" Line – 24.8 gal/mile

INSPECTION

- Ø Minimum Retroreflectivity Requirements
 - | White 250 mcd/m²/lux
 - | Yellow 175 mcd/m²/lux
- Ø Readings taken 30-60 days after application
 - | KM202 – Portable Readings (LTL 2000)
 - | KM203 – Mobile Readings (Mobile Van)

PAYMENT

- Ø 60% After application
- Ø 40% After passing
- Ø Incentive Payment Schedule
 - | Based on retroreflectivity and contract performance

QC/QA Requirements

QUALITY CONTROL PLAN

- Ø QC COORDINATOR
 - | Designated by Contractor
 - | Performs QC Inspection
- Ø QA INSPECTOR
 - | Designated by State Forces
- Ø DISPUTE RESOLUTION
 - | Defines chain of command

QC COORDINATOR

- Ø Hold current qualification from the Cabinet as a Pavement Marking Inspection Technician

- Ø Oversee Contractor's evaluation of applied lines

QC INSPECTION

- Ø Perform KM 202 for all striping applied

- Ø Provide completed test reports to the Project Engineer

- Ø Meet with the Project Engineer to review project throughout execution of the contract

QA INSPECTION

- Ø Verify readings of the QC Coordinator

- Ø Meet with the QC Coordinator to review progress and compare instrument readings

- Ø Compare QC and QA data for payment

DISPUTE RESOLUTIONS

"If a dispute should arise regarding the acceptability of the Contractor's QC test results..."



STEP 1.

- ⊗ Differing Retroreflectivity Values > 10%
 - ┆ Compare readings taken by QA and QC
 - ┆ Additional readings *if* QA testing indicates failure
- ⊗ Differing Retroreflectivity Values < 10%
 - ┆ Accept the QC readings



STEP 2.

- ⊗ Determine the reason for any variance > 10% to resolve the discrepancies.
- ⊗ Additional readings are not necessary if both the QC and QA readings are passing



STEP 3.

If the variance indicates a change in pay establish new zones within the disputed segments and obtain additional readings with both machines.





STEP 4.

'If the retroreflectivity values obtained during the QA testing indicate failure within the segment but the mean values differ by less than 10% and the QC's readings are passing then the QC readings will be accepted for payment.'



STEP 5.

Ø Final Resolution:

If the discrepancy cannot be resolved:
Central Office Maintenance or Materials
Personnel must be notified. Additional
readings will be obtained to determine
which set of original readings will be
considered final.





SECTION 713 • PERMANENT PAVEMENT STRIPING

713.01 DESCRIPTION. Furnish and apply striping paint to provide lane lines, edgelines, and gore markings as specified in the Contract.

713.02 MATERIALS AND EQUIPMENT.

713.02.01 Paint. Conform to Section 842.

713.02.02 Drop On Glass Beads. Use beads that will ensure the pavement marking material will meet retroreflectivity requirements. The Department will evaluate the beads as part of the marking system through retroreflectivity readings.

713.02.03 Application Equipment. Use a self-propelled striper capable of heating the paint to provide uniform flow and enhance quick drying of the paint. Ensure that the striper has a guide boom or optical pointer to attain smooth and straight lines. Ensure that the equipment maintains proper paint pressure at all times. Provide equipment capable of applying a single line or parallel lines of the specified width and in any combination of a skip line and a solid line in one pass.

Provide equipment with a paint cutoff device to provide clean, square marking ends of the paint lines.

Equip the paint pots or tanks with an agitator that will keep the paint thoroughly mixed.

Provide equipment with bead dispensers, one for each paint spray gun, placed such that the beads are applied to the paint almost instantly as the paint is being placed on the roadway surface. Design and align the bead dispensers so that beads are applied under air pressure uniformly to the entire surface of the paint lines. Equip the bead dispensers with cutoff controls synchronized with the cutoff controls for the paint spray guns.

713.03 CONSTRUCTION. Provide yellow centerline markings, which are defined as those separating traffic moving in opposite directions. Provide white lane line markings, which are defined as those separating traffic moving in the same direction. Ensure that these markings are skip lines and solid lines as required by Part 3 of the MUTCD. Ensure that edge lines are solid lines, and determine the color from Part 3 of the MUTCD.

On interstates and parkways, and roadways with pre-existing 6-inch wide striping, install pavement striping that is 6 inches in width. On other routes, install pavement striping that is 4 inches in width. Ensure that all lines have clean edges with a width tolerance of plus 1/2 inch. The Engineer may waive the tolerances when deviations are caused by undulation in the pavement surface.

Construct skip lines with a stripe-to-gap ratio of a 10-foot paint stripe to a 30-foot gap. Ensure that the length of the stripe is between 10 and 10 1/2 feet. Ensure that the stripe-gap cycle is between 40 and 40 1/2 feet.

Apply striping before sunset on new pavement that is to be driven over by the public. When rain or other unavoidable occurrences prevent marking before sunset, mark the pavement during daylight hours as soon as conditions permit.

713.03.01 Records. On resurfacing, pavement restoration, and pavement rehabilitation projects, prepare and keep a written record of the locations of existing pavement markings, and furnish a copy to the Engineer before removing or obliterating the markings.

713.03.02 Pavement Surface Preparation. Clean grease, oil, mud, dust, dirt, grass, loose gravel, or other deleterious material from the surface where pavement markings are to be applied. Use only Engineer approved cleaning methods.

713.03.03 Paint Application. On resurfacing, pavement restoration, and pavement

rehabilitation projects, put back the recorded existing pavement markings as modified by the Engineer. On new construction, place the markings as the Contract specifies or as the Engineer designates.

Apply paint at a rate of not less than 16.5 gallons per mile of solid 4-inch line and 24.8 gallons per mile of solid 6-inch line. Apply glass beads at a rate of not less than 6 pounds per gallon.

713.03.04 Marking Removal. Remove all markings made in error or not conforming to the traffic operation in use. Remove markings by either an abrasion or burning process to the satisfaction of the Engineer. Do not paint with asphalt binder or other material to obliterate the markings.

713.03.05 Proving Period. A proving period will follow the application of the permanent pavement striping. During this period, the Engineer will make such observations as are necessary to determine if the markings are acceptable. The proving period begins when the facility is opened to traffic.

- A) **Requirements.** The minimum retroreflectivity requirements at the end of the proving period, as measured with a LTL 2000 or a mobile retroreflectometer (30 M geometry), are as follows:

White:	175 mcd/lux/square meter
Yellow:	150 mcd/lux/square meter

The Department will take these measurements between 30 and 60 days after the start of the proving period, with acceptance based on KM 202 for LTL 2000 readings and KM 203 for mobile readings. If the Department determines that the markings are acceptable, the installation of the markings will be considered complete.

- B) **Failure.** For any one-mile section and each gore area during the proving period, the Department will consider the section defective when the retroreflectivity falls below the minimum required. The Department will consider each edge line, centerline, lane line and gore area marking separately.
- C) **Corrective Work.** If a line is found to be defective, repair or remove and replace the line. Perform pavement marking replacement according to the requirements specified in this subsection for the initial application. The corrective work will be subject to a proving period as listed above.

713.03.06 Acceptance of Non-Specification Markings. If weather conditions allow, perform corrective work to bring striping retroreflectivity into conformance. If corrective work has been performed and the work meets all requirements except for minimum retroreflectivity, the Department may accept the work according to Subsection 105.04. When the Engineer determines that the markings may be left in place, the Department will accept them at a reduction in the Contract unit bid price according to the Acceptance Pay Schedule. Additionally, the Engineer may remove the striping crew for the remainder of the project according to Subsection 108.06 Part A).

The Engineer may also apply this section when corrective work cannot be performed due to weather.

Acceptance Pay Schedule – White	
156 to 174 mcd/lux/square meter	– 50% pay
138 to 155 mcd/lux/square meter	– 25% pay
120 to 137 mcd/lux/square meter	– 0% pay
< 120 mcd/lux/square meter	– unacceptable

Acceptance Pay Schedule – Yellow
126 to 149 mcd/lux/square meter – 50% pay
103 to 125 mcd/lux/square meter – 25% pay
80 to 102 mcd/lux/square meter – 0% pay
< 80 mcd/lux/square meter – unacceptable

713.04 MEASUREMENT. The Department will measure the quantity in linear feet. When a bid item is not included for gore markings, the Department will measure the quantity by converting the actual length and width of line installed to an equivalent length of the normal width line on that section of roadway.

713.05 PAYMENT. The Department will make payment for the completed and accepted quantities under the following:

<u>Code</u>	<u>Pay Item</u>	<u>Pay Unit</u>
6514-6517	Pavement Striping - Permanent Paint, Width	Linear Foot

The Department will consider payment as full compensation for all work required under this section.

SECTION 714 • DURABLE PAVEMENT STRIPING

714.01 DESCRIPTION. Furnish and install durable marking materials, thermoplastic or Type I tape, to provide lane lines, edgelines, and gore markings as specified in the Contract.

714.02 MATERIALS AND EQUIPMENT.

714.02.01 Thermoplastic. Conform to Section 837.

714.02.02 Type I Tape. Conform to Section 836.

714.02.03 Binder. Furnish a binder that the manufacturer of the pavement marking material recommends and the Engineer approves. Provide a binder that forms a continuous film that dries rapidly and adheres to the pavement. Provide a material that does not discolor or cause any noticeable change in the appearance of the pavement outside of the finished pavement marking. Submit the material and method of application to the Engineer and obtain written approval from the Engineer and the manufacturer of the pavement marking material before applying.

714.02.04 Drop On Glass Beads. Use beads that will ensure the pavement marking material will meet retroreflectivity requirements. The Department will evaluate the beads as part of the marking system through retroreflectivity readings.

714.02.05 Thermoplastic Application Equipment. Provide equipment with an extrusion die that simultaneously deposits and shapes lines at a minimum thickness of 90 mils on the pavement surface. Do not use spray and ribbon gun applicators.

Ensure the application equipment conforms to the following:

- 1) Capable of providing continuous and uniform heat to maintain the material between 400 and 440 °F throughout the mixing, conveying, and dispensing.
- 2) The kettle is capable of continuous agitation during mixing and heated storage and is equipped with an automatic thermostat control device and material thermometer.
- 3) Motorized and capable of applying a uniform line at a rate of 3 mph.
- 4) Equipped with a cutoff device that provides clean, square stripe ends.
- 5) Equipped with an automatic bead dispenser.

714.03 CONSTRUCTION. Provide yellow centerline markings, which are defined as those separating traffic moving in opposite directions. Provide white lane line markings, which are defined as those separating traffic moving in the same direction. Ensure that these markings are skip lines and solid lines as required by Part 3 of the MUTCD. Ensure that edge lines are solid lines, and determine the color from Part 3 of the MUTCD.

Install pavement striping at the width specified in the Contract. Ensure that all lines have clean edges with a width tolerance of plus 1/2 inch. The Engineer may waive the tolerances when deviations are caused by undulation in the pavement surface.

Construct skip lines with a stripe-to-gap ratio of a 10-foot stripe to a 30-foot gap. Ensure that the length of the stripe is between 10 and 10.5 feet. Ensure that the stripe-gap cycle is between 40 and 40.5 feet.

714.03.01 Layout. Install all pavement markings according to Part 3 of the MUTCD and the following requirements.

Make the width of lane lines and edgelines as specified in the Plans or as the Engineer directs. Make lines for gore area markings twice the normal width line for that section of roadway.

Unless striping plans are included in the proposal or otherwise directed by the Engineer, install gore area markings as shown in Figures 3B-8 and 3B-9 of the MUTCD. Do not use the optional markings shown (transverse lines in the neutral area and dotted extension of the right edgeline).

Due to the possibility that water may be retained on the roadway by the thermoplastic edgelines, place a one foot gap every 20 feet in all thermoplastic edgelines. Do not install gaps for taped edgelines.

Offset longitudinal lines at least 2 inches from longitudinal pavement construction joints. Offset longitudinal lane lines on multi-lane highways 2 inches towards the median.

On resurfacing, pavement restoration, and pavement rehabilitation projects, prepare and keep a written record of the locations of existing pavement markings, and furnish a copy to the Engineer before removing or obliterating the markings. The Engineer will notify you of any changes to the existing markings.

Before applying the pavement marking material, pre-mark the pavement surface and obtain the Engineer's approval of the proposed location, alignment, and control guides.

714.03.02 Surface Preparation.

- 1) Remove existing pavement markings and clean grease, oil, mud, dust, dirt, grass, loose gravel, or other deleterious material from the surface where pavement markings are to be applied, as directed by, and by methods acceptable to, the Engineer.
- 2) Remove the existing pavement markings until a minimum of 90 percent of the pavement surface is uniformly exposed throughout. Ensure that the pavement surface is in proper condition for successful bonding of the pavement markings and provides a neat appearance. Do not leave any loose or flaking existing pavement markings.
- 3) When removing the existing pavement markings, ensure that the finished pavement surface is not damaged or left in a condition that may mislead or misdirect the motorist. Repair any damage to the pavement, pavement joint materials, or the pavement surface caused by the removal of the existing pavement markings in a manner acceptable to the Engineer. After completing these operations, use compressed air to blow clean the pavement surface of residue and debris resulting from the removal of existing pavement markings.
- 4) When removal of existing pavement markings and objectionable materials obscures existing pavement markings of a lane occupied by public traffic, immediately remove the residue, including dust, from the surface being treated. Obtain the Engineer's approval of the removal methods.
- 5) Place the final pavement markings on the same day that the existing pavement markings are removed.
- 6) On concrete surfaces and as the Engineer directs on older asphalt pavements, apply binder to the area where placing pavement marking material.
- 7) On new concrete pavement surfaces, remove the curing compound from the pavement surface before applying the binder and the pavement marking material.

714.03.03 Application.

- A) **Type I Tape.** Apply according to the manufacturer's recommendations. When applied to concrete, cut the tape at all joints.
- B) **Thermoplastic.** Rather than installing thermoplastic pavement markings on fresh asphalt, the Department will allow temporary striping with paint. When choosing this option, cover the temporary striping with the thermoplastic pavement markings within 30 calendar days. The Department will not require removal of the interim pavement marking paint before applying the thermoplastic pavement markings.

Install the thermoplastic material at a minimum thickness of 90 mils on the pavement surface in a melted state at a temperature from 400 and 440 °F.

Apply additional glass beads by drop-on or pressure spray methods in sufficient quantities to obtain the retroreflectivity requirements specified in Subsection 714.03.06.

Verify the adhesion of the thermoplastic to asphalt pavements by performing bond checks, at least 4 per mile of line, as follows. Approximately 60 to 120 seconds after applying a thermoplastic line to the roadway surface, cut and lift approximately a 6-inch section of thermoplastic. The thermoplastic is successfully bonding to the pavement surface if a layer of asphalt clings to the removed thermoplastic stripe and the pavement surface under the removed stripe is shiny and black.

Provide finished markings that are continuous and uniform in shape, having clear and sharp dimensions. Ensure that all lines have well-defined edges.

714.03.04 Restrictions. Do not apply the pavement marking material when air and pavement temperatures are below 50 °F.

Do not apply the pavement marking material when the surface of the pavement contains evidence of moisture in amounts significant enough to prevent the pavement marking material from bonding to the pavement. Significant amounts of moisture can be caused by heavy dew or very humid nights as well as from rainfall.

If encountering significant amounts of moisture while applying the thermoplastic, the Contractor, at his own risk, may attempt to apply thermoplastic subject to the following restrictions. Heat the thermoplastic material to the upper temperature limit specified by the manufacturer, and apply a test line on the pavement. Perform a bond check according to Subsection 714.03.03. If the thermoplastic successfully bonds to the pavement continue to apply thermoplastic lines, provided there is evidence that the moisture is escaping through the surface of the line, as indicated by very small pin holes. If there is excessive moisture, as indicated by larger sized holes or bubbles on the surface of the line, do not apply thermoplastic until the moisture can be effectively dealt with. Perform a sufficient number of bond checks to ensure that the thermoplastic is bonding to the pavement.

714.03.05 Project Conflicts. When other construction projects are in progress within the limits of the designated work areas, install no pavement markings that will be removed or damaged by immediate subsequent construction. The Engineer will give notification of all conflicting construction projects. Schedule the installation of pavement markings after completion of the conflicting construction. When scheduling is impossible or creates an undue hardship, the Engineer will delete the intersection from this project.

714.03.06 Proving Period for Durable Markings. A 180 day proving period will follow the application of the durable markings. During this period, the Engineer will make such observations as are necessary to determine if the markings are acceptable. The proving period begins when the facility is opened to traffic.

A) Requirements.

- 1) Type I Tape. During the proving period, ensure that the pavement marking material shows no signs of failure due to blistering, excessive cracking, bleeding, staining, discoloration, oil content of the pavement materials, deterioration due to contact with grease deposits, oil, diesel fuel, or gasoline drippings, chipping, spalling, poor adhesion to the pavement, loss of retroreflectivity, vehicular damage, and normal wear. Type I Tape is manufactured off site and warranted by the manufacturer to meet certain retroreflective requirements. As long as the material is adequately bonded to the surface and shows no sign of failure due to the other items listed in Subsection 714.03.06 A) 1), retroreflectivity readings will not be required. In the absence of readings, the Department will accept tape based on a nighttime visual observation.

- 2) Thermoplastic. During the proving period, ensure that the thermoplastic pavement marking material shows no signs of failure due to blistering, excessive cracking, bleeding, staining, discoloration, oil content of the pavement materials, smearing or spreading under heat, deterioration due to contact with grease deposits, oil, diesel fuel, or gasoline drippings, chipping, spalling, poor adhesion to the pavement materials, loss of retroreflectivity, vehicular damage and normal wear.

The minimum retroreflectivity requirements at the end of the proving period, as measured with a LTL 2000, LTL 2000Y, or Department approved 30M geometry mobile instrument are as follows:

White:	300 mcd/lux/square meter
Yellow:	175 mcd/lux/square meter

The Department will take these measurements between 150 and 210 days after the start of the proving period, basing acceptance on KM 202 for LTL 2000 readings and KM 203 for mobile readings. If the Department determines that the markings are acceptable, the installation of the markings will be considered complete.

- B) Failure.** For any one mile section and each gore area during the proving period, the Department will consider the section defective when the retroreflectivity falls below the minimum required or more than 10 percent of the material fails to meet the other requirements of A) above. The Department will consider each edge line, centerline, lane line and gore area marking separately.
- C) Corrective Work.** If a line is found to be defective, repair or remove and replace the line. Perform pavement marking replacement according to the requirements specified in this subsection for the initial application. The corrective work will be subject to a proving period as listed above.

714.03.07 Marking Removal. Remove all markings made in error or not conforming to the traffic operation in use. Remove markings by either an abrasion or burning process to the satisfaction of the Engineer. Do not paint with asphalt binder or other material to obliterate the markings.

714.03.08 Acceptance of Non-Specification Thermoplastic Markings. When reasonably acceptable work has been produced but retroreflectivity requirements are not met, the Department may accept the work according to Subsection 105.04. When the Engineer determines that the markings may be left in place, the Department will accept them at a reduction in the Contract unit bid price according to Acceptance Pay Schedule for Thermoplastic.

714.04 MEASUREMENT. When a bid item is not included for gore markings, the Department will measure the quantity by converting the actual length and width of line installed to an equivalent length of the normal width line on that section of roadway.

714.04.01 Thermoplastic Pavement Markings. The Department will measure for payment by the units listed in the Quantity Summary. The Department will not measure sampling, testing, surface preparation, pre-marking, interim marking, and binder application for payment and will consider them incidental to the thermoplastic bid items. The Department will not measure corrective work for payment.

714.04.02 Durable Pavement Markings, Type I. The Department will measure for payment by the units listed in the Quantity Summary. The Department will not measure sampling, testing, surface preparation, pre-marking, and binder application for payment and will consider them incidental to the pavement marking bid items. Corrective work will not be measured for payment.

714.04.03 Pavement Striping Removal. When listed as a bid item, the Department will measure for payment by the units listed in the Quantity Summary. The Department will not measure for payment the removal of existing pavement markings that have not been authorized by the Engineer. When the Contract does not list a bid item, the Department will consider existing pavement marking removal incidental to the other pavement marking bid items. The Department will not measure for payment any corrective work required due to the removal work.

714.05 PAYMENT. The Department will make payment upon completion of the work. If after the proving period the markings do not meet minimum retroreflectivity requirements, the Department will adjust the payment or require corrective work according to the following:

ACCEPTANCE PAY SCHEDULE FOR THERMOPLASTIC		
Pay Value	White mcd/lux/square meter	Yellow mcd/lux/square meter
1.00	300	175
0.50	200-299	100-174
Remove and Replace	< 200	< 100

<u>Code</u>	<u>Pay Item</u>	<u>Pay Unit</u>
6540-6547	Pavement Striping - Thermoplastic, width, color	Linear Foot
6554-6561	Pavement Striping - Durable Type I Tape, width, color	Linear Foot

The Department will consider payment as full compensation for all work required under this section.

SECTION 717 • THERMOPLASTIC INTERSECTION MARKINGS

717.01 DESCRIPTION. Furnish and install thermoplastic intersection markings (Stop Bars, Crosswalks, Turn Arrows, etc.) by either a machine applied, screed extrusion process or by applying preformed thermoplastic intersection marking material.

717.02 MATERIALS AND EQUIPMENT.

717.02.01 Preformed Thermoplastic Intersection Marking Material. Select from the Department's List of Approved Materials.

717.02.02 Extruded Thermoplastic Pavement Marking Material. Conform to Section 837.

717.02.03 Binder. Conform to Subsection 714.02.03

717.02.04 Drop On Glass Beads. Use beads that will ensure the pavement marking material will meet retroreflectivity requirements. The Department will evaluate the beads as part of the marking system through retroreflectivity readings.

717.02.05 Extruded Thermoplastic Application Equipment. Provide equipment with a shaping die that simultaneously deposits and shapes lines at a minimum thickness of 90 mils on the pavement surface. Do not use spray and ribbon gun applicators.

Ensure the application equipment conforms to the following:

- 1) Capable of providing continuous and uniform heat to maintain the material between 400 and 440 °F throughout the mixing, conveying, and dispensing.
- 2) The kettle is capable of continuous agitation during mixing and heated storage and is equipped with an automatic thermostat control device and material thermometer.
- 3) Equipped with a cutoff device that provides clean, square stripe ends.
- 4) Equipped with an automatic bead dispenser.

717.03 CONSTRUCTION.

717.03.01 Layout. On resurfacing, pavement restoration, and pavement rehabilitation projects, prepare and keep a written record of the locations of existing pavement markings, and furnish a copy to the Engineer before removing or obliterating the markings. The Engineer will notify you of any changes to the existing markings.

On new construction, the Department will provide more detailed information for each intersection prior to beginning work. This information will consist of plans, a drawing of each intersection, or an inspector to work with each crew to layout the markings in the field.

Before applying the pavement marking material, pre-mark the pavement surface and obtain the Engineer's approval of the proposed location, alignment, and control guides.

717.03.02 Surface Preparation. Clean all grease, oil, mud, dust, dirt, grass, loose gravel, or other deleterious material from the surface where pavement markings are to be applied as directed by, and by methods acceptable to, the Engineer.

On concrete surfaces and as the Engineer directs on older asphalt pavements, apply binder to the area where placing pavement marking material. Ensure that all solvents have evaporated from the binder before applying the marking material. On new concrete pavement surfaces, remove the curing compound from the pavement surface before applying the binder and the pavement marking material.

717.03.03 Application. Install extruded thermoplastic at a minimum thickness of 90 mils on the pavement surface in a melted state at a temperature from 400 and 440 °F. Install preformed thermoplastic according to manufacturer's instructions at a minimum thickness of 125 mils. Apply additional glass beads by a drop-on method at a rate that satisfies the retroreflectivity requirements of Subsection 717.03.05.

When installing symbols and legends (turn arrows, the word “ONLY” etc.) by the extrusion process, ensure that the finished markings conform to the standard size and shape in the Manual on Uniform Traffic Control Devices.

Verify the adhesion of the thermoplastic to asphalt pavements by performing bond checks as follows. Approximately 60 to 120 seconds after applying the thermoplastic material cut and lift approximately a 6-inch section. The thermoplastic is successfully bonding to the pavement surface if a layer of asphalt clings to the removed thermoplastic and the pavement surface under the removed section is shiny and black.

Ensure that finished markings are continuous and uniform in shape having clear and sharp edges with uniform bead distribution across the entire width and length of the line, symbol, or legend.

717.03.04 Restrictions. Do not apply the pavement marking material when air and pavement temperatures are below 50 °F.

Do not apply the pavement marking material when the surface of the pavement contains evidence of moisture in amounts significant enough to prevent the pavement marking material from bonding to the pavement. Significant amounts of moisture can be caused by heavy dew or very humid nights as well as from rainfall.

If encountering significant amounts of moisture while applying the thermoplastic, the Contractor, at his own risk, may attempt to apply the thermoplastic material subject to the following restrictions. Heat the thermoplastic material to the upper temperature limit specified by the manufacturer, and apply a test line on the pavement. Perform a bond check according to Subsection 717.03.03. If the thermoplastic successfully bonds to the pavement continue to apply thermoplastic material, provided there is evidence that the moisture is escaping through the surface of the material, as indicated by very small pinholes. If there is excessive moisture, as indicated by larger sized holes or bubbles on the surface of the material, do not apply thermoplastic until the moisture can be effectively dealt with. Perform a sufficient number of bond checks to ensure that the thermoplastic is bonding to the pavement.

717.03.05 Proving Period. A proving period of 180 days will follow the application of the durable markings. During this period, the Engineer will make such observations as are necessary to determine if the markings are acceptable. The proving period begins when the facility is opened to traffic.

- A) Requirements.** During the proving period, ensure that the material shows no signs of failure due to blistering, excessive cracking, bleeding, staining, discoloration, oil content of the pavement materials, smearing or spreading under heat, deterioration due to contact with grease deposits, oil, diesel fuel, or gasoline drippings, chipping, spalling, poor adhesion to the pavement materials, loss of retroreflectivity, vehicular damage and normal wear.

The minimum retroreflectivity requirements at the end of the proving period, as measured with a LTL2000, are as follows:

White: 300 mcd/lux/square meter
Yellow: 175 mcd/lux/square meter

The Department will take these measurements between 30 and 60 days after the start of the proving period, with acceptance based on KM 201. If the Department determines that the markings are acceptable, the installation of the markings will be considered complete.

- B) Failure.** The Department will consider any marking defective when the readings for that marking do not satisfy the retroreflectivity requirements or more than 10 percent of the material fails to meet the other requirements of A) above. The Department will consider each marking separately.
- C) Corrective Work.** If any marking is found to be defective, repair or remove and replace the marking. Perform pavement marking replacement according to the requirements specified in this subsection for the initial application. The corrective work will be subject to a proving period as listed above.

717.03.06 Marking Removal. Remove all markings made in error or not conforming to the traffic operation in use. Remove markings by either an abrasion or burning process to the satisfaction of the Engineer. Do not paint with asphalt binder or other material to obliterate the markings.

717.03.07 Acceptance of Non-Specification Markings. When reasonably acceptable work has been produced but retroreflectivity requirements are not met, the Department may accept the work according to Subsection 105.04. When the Engineer determines that the markings may be left in place, the Department will accept them at a reduction in the Contract unit bid price according to Acceptance Pay Schedule for Thermoplastic. The Department will not consider these procedures a means to continue accepting non-specification markings.

717.04 MEASUREMENT. The Department will measure the intersection markings on a per unit basis for items listed in the Quantity Summary.

The Department will not measure the removal of existing markings, layout, surface preparation, binder, glass beads, or testing for payment and will consider them incidental to the installation of the new marking. The Department will exclude the gaps when measuring dotted lane line extensions.

717.05 PAYMENT. The Department will make payment for the completed and accepted quantities under the following:

ACCEPTANCE PAY SCHEDULE		
Pay Value	White mcd/lux/square meter	Yellow mcd/lux/square meter
1.00	300	175
0.50	200-299	100-174
Remove and replace	<200	<100

<u>Code</u>	<u>Pay Item</u>	<u>Pay Unit</u>
6565, 6566	Pavement Marking, Thermoplastic X-Walk, Size	Linear Foot
6567, 6568	Pavement Marking, Thermoplastic Stop Bar, Size	Linear Foot
6569	Pavement Marking, Thermoplastic Cross Hatch	Square Foot
6572	Pavement Marking, Dotted Lane Extension	Linear Foot
6573-6575	Pavement Marking, Thermoplastic Arrow, Type	Each
6576	Pavement Marking, Thermoplastic "ONLY"	Each
----	Pavement Marking, Thermoplastic U-Turn Arrow	Each

The Department will consider payment as full compensation for all work required under this section.

SECTION 842 • PAVEMENT STRIPING PAINT

842.01 DESCRIPTION. This section covers quick-drying pavement striping paint for permanent applications.

842.02 APPROVAL. Select materials that conform to the composition requirements below. Submit initial samples for approval before beginning striping operations. The initial sample may be sent from the manufacturer of the paint. The Department will randomly sample and evaluate the paint each week that the striping operations are in progress.

PAINT COMPOSITION		
Property and Test Method	Yellow	White
Color (CIELAB) Spectrophotometer using a D65 illuminant at 45° illumination and 0° viewing with a 2° observer	L* 80.80 a* 19.04 b* 88.57 With a maximum variation of 2.0 ΔE_{cmc}	L* 94.92 a* -2.18 b* 3.10 With a maximum variation of 2.0 ΔE_{cmc}
Lead ASTM D 3335	< 5ppm	<5ppm
TiO ₂ ASTM D 4764	NA	10% by wt. of pigment min.
VOC ASTM D 2369 and D 4017	1.25-lb/gal max.	1.25-lb/gal max.
Contrast Ratio (at 15 mils wft.)	0.97	0.99

842.03 ACCEPTANCE PROCEDURES FOR NON-SPECIFICATION PAVEMENT STRIPING PAINT. When non-specification paint is inadvertently incorporated into the work the Department will accept the material with a reduction in pay. The percentage deduction is cumulative based on its compositional properties, but will not exceed 60 percent. The Department will calculate the payment reduction on the unit bid price for the routes where the non-specification paint was used.

PAVEMENT STRIPING PAINT REDUCTION SCHEDULE					
Non-conforming Property	Color	Lead	TiO ₂	VOC	Contrast
Reduction Rate	10%	60%	10%	60%	10%

WATERBORNE PAINT STRIPING SPECIFICATIONS for FY 2004

GENERAL PROVISIONS

Work performed under this contract shall be in conformance with Commonwealth of Kentucky, Transportation Cabinet, Department of Highways' Standard Specifications for Road and Bridge Construction, 2000 Edition, applicable Special Provisions and general specifications included in this proposal. The U.S. Department of Transportation's Manual on Uniform Traffic Control Devices (MUTCD), Current Edition, with all published changes and additions shall also apply to this contract.

SCOPE OF WORK

The work performed under this contract shall consist of furnishing and applying waterborne paint, reflectorized with glass beads, to the sections of roadway to be provided at the pre-construction meeting. This contract is for the installation of centerlines, lane lines, edgelines, and gore markings only. Special markings such as stop bars, crosswalks, cross-hatching, railroad markings, etc. are not to be installed under this contract.

Intersection approach markings such as the edgelines of large painted islands or edgelines on mountable medians may be included at the discretion of the Engineer provided they can be painted by the striping truck. Markings that would require application by equipment other than the striping truck are not to be installed under this contract.

The vast majority of the work performed under this contract will consist of retracing existing lines. The Department will be responsible for pre-marking any section of roadway where the old markings are no longer visible or where the existing markings are to be changed. Edgelines shall not be installed on any section of roadway where edgelines do not currently exist without authorization from the Engineer.

QUALITY CONTROL/QUALITY ASSURANCE

The Contractor is responsible for Quality Control (QC) and will establish and maintain an effective quality control plan.

The Contractor shall designate a Quality Control Coordinator for the project who will be the contact person for any questions or concerns regarding the quality of the work performed under this contract. The Quality Control Coordinator shall:

- Hold current qualification from the Department as a Pavement Marking Inspection Technician;
- Plan and oversee the Contractor's evaluation of the lines applied on the project;

- Perform KM-202, for all striping applied and provide completed test reports to the Engineer;
- Adjust the application process to consistently produce the quality of line desired;
- Notify the Engineer of any changes in the striping work plan that are determined necessary;
- Inform and mobilize crews to complete restriping or corrective work (after notification by the Department);
- Supply the appropriate certifications for paint and beads to the Engineer assigned to the particular project ;
- Track the quantities of materials supplied by the vendors and applied by the painting crew; and
- Meet with the Engineer to discuss and/or conduct field reviews on the project throughout the execution of the contract.

At the Pre-construction Conference, the Contractor shall furnish the Department a quality control plan that covers in detail the following items:

- the name, address, phone and fax numbers for the Quality Control Coordinator;
- the names of individuals other than the Quality Control Coordinator taking readings in accordance with KM202 (these people shall hold qualification from the Department as Pavement Marking Inspection Technicians)
- an overall work plan which states the estimated starting and completion dates for the entire project, the number of crews to be used on the project and a general description of how the project will be completed;
- a description of the striping equipment to be used on the project, including make and model of each striper, minimum and maximum operating speeds, and type of instruments to be used to calibrate the flow of paint and beads;
- the frequency and method to be used to monitor application rates and quality of the line (specifically with regard to retroreflectivity, width, thickness, bead distribution, tracing accuracy, etc.);
- a list of paint(s) and bead(s) to be used in this contract along with a statement from the paint manufacturer that indicates the application temperature of the paint, the recommended ambient and road temperatures, and guidelines for any other environmental factors that would adversely affect the successful performance of the paint; and
- the contact person, phone and fax numbers for reporting claims for paint on vehicles.

Acceptance of the Contractor's quality control plan is required prior to the start of work. The Department reserves the right to require the Contractor to make changes in his quality control plan and operations to obtain the quality specified in the contract.

After acceptance by the Department, the Contractor shall notify the Engineer in writing of any proposed change. Proposed changes are subject to acceptance by the Department.

The Department will perform Quality Assurance (QA) testing on (at least) 20% of the test data submitted by the Contractor. QA testing is intended to verify the Contractors QC test data. Upon receipt of the Contractors' test report for a section, the QA Inspector will randomly select (at least) 20% of the segments for evaluation and test in accordance with KM202 (with the exception of the evaluation period if greater than 60 days old) within 2 weeks of the QC testing. The Inspector will evaluate zones within the segments designated by the QC test report.

The Department will base payment on the Contractor's QC test results if:

- the QC results (for each segment evaluated) are passing and
- the QC and QA mean values differ by less than 10%.

If a dispute should arise regarding the acceptability of the Contractor's QC test results the dispute resolution shall be conducted as follows:

1. If the retroreflectivity values obtained during the QA testing indicate failure within the segment or the mean values differ by more than 10 %; the Contractor and the QA Inspector will compare the readings taken with the two instruments. Additional readings will be taken within that segment, if necessary.
2. If the variance between QC and QA testing does not indicate a change in the pay quantities for the segment (i.e. QC and QA readings are both passing but there is more than a 10% difference between the mean values) no additional readings will be necessary. However, an effort should be made as soon as possible, when a discrepancy between mean values is greater than 10%, to determine what has caused the discrepancy and how it can be resolved.
3. If the variance between QC and QA testing does indicate a change in the pay quantities for the section (i.e. QC readings are bonus and QA readings are only passing and there is more than a 10% difference between the mean values) additional readings will be necessary. To obtain additional readings, the QC and the QA will establish new zones, within the segments in question, to represent the section of striping. The QC and QA inspectors will perform the required evaluations on these zones together.
4. If the mean of the readings taken during the evaluation (detailed in Section 3) do not agree (within the allowed 10% variance) and there is a dispute regarding the pay factor; or if resolution to the variance cannot be reached by the QC and QA Inspectors; additional testing along with the QC and QA inspectors, will be performed by the Central Office Division of Maintenance and/or Division of Materials to resolve the dispute. The readings obtained by the Central Office representatives will be taken in accordance with KM202 (with the exception of the evaluation period if greater than 60 days old). The readings will be obtained within two weeks of a written request from the District Quality Assurance Inspector and the Contractors' Quality Control Inspector for all sections in dispute. The readings taken by Central

Office personnel will be used to determine whether the original QC or QA readings will be considered final for the sections in dispute and payment will be based on those original readings.

The Department reserves the right to take over the QC portion of testing. In the event that the Department exercises this option, the Contractor will incur the cost of testing performed by the Department.

The Department will furnish the Contractor with a blank copy of the Contractors Daily Striping Report (DSR). The Contractor shall complete and furnish this DSR to the Resident Engineer's office daily for each crew for each color. The information on the DSR shall reflect the milepoints and quantities for striping completed for that day for that crew. The Contractor shall also include with the DSR the paint certification for paint used on that day's striping.

MATERIALS

Select Materials for this project to meet the performance requirements detailed in this contract document. Initial samples must be submitted for approval prior to initiation of the striping operation. The initial sample may be sent from the manufacturer of the paint. The following compositional requirements will be evaluated on samples randomly obtained by Department representatives during each week that striping operations are in progress:

<u>PAINTS</u>	YELLOW	WHITE
(1) COLOR	595B-38907	595B-37925
L*	80.80	94.92
a*	19.04	-2.18
b*	88.57	3.10
(2) LEAD:	< 5ppm	<5ppm
(3) TiO ₂ :	NA	10% by wt. of pigment min.
(4) VOC:	150-g/liter max.	150-g/liter max.
(5) CONTRAST RATIO (MIN):	0.97	0.99

Test Methods to be used in the determination of these properties:

- (1) Allowable variation of the color, measured in the laboratory, will be $2.0 \Delta E_{cmc}$ from the referenced standard color. These values shall be obtained from a spectrophotometer utilizing a D65 illuminant at 45° illumination and 0° viewing with a 2° observer. Readings will be taken only over the black portion of the Leneta sheet on a 15 mil (wft) draw down.
- (2) ASTM D 3335 "Low Concentrations of Lead, Cadmium and Cobalt in Paint by Atomic Absorption Spectroscopy"
- (3) ASTM D 4764 "Determination by X-Ray Fluorescence of Titanium Dioxide Content in Paint"
- (4) ASTM D 2369 "Test Method for Volatile Content of Coatings"
And
ASTM D 4017 "Test Method for Water in Paints and Paint Materials by Karl Fischer Method"
- (5) ASTM D 2805 "Hiding Power of Paints by Reflectometry" with the following exceptions the contrast ratio will be determined on a 15 mil (wft) draw down (on a Leneta form 2c), allowed to dry for 16 to 24 hours at $73 \pm 2^\circ$ F, and 50% relative humidity.

If randomly obtained samples do not meet the compositional criteria, the following deductions will be assessed to the striping bid items for the routes where the failing paint was used:

COLOR:	10% each day used
LEAD:	60% each day used
TiO ₂ :	10% each day used
VOC:	60% each day used
CONTRAST RATIO:	10% each day used

If the contractor cannot produce documentation detailing the number of days the failing material was used on this project, the deduction will be based on the quantity of striping that the failing batch of paint represents. The percentage deduction for use of materials which do not meet the compositional criteria will be cumulative, but will not exceed 60% of the payment for the striping bid items for the routes where the failing paint was used.

If two random samples fail to meet minimum compositional requirements, striping

operations will be discontinued. Before the Contractor is allowed to resume striping, the Department will randomly sample and test each lot of paint the contractor has in stock at the storage location.

For lots of paint that fail to meet the minimum compositional criteria, the stock material will be rejected. The contractor will be required to remove all failing paint from his central storage location. Lots that are tested and found to be in compliance with the compositional requirements may be used.

BEADS: Beads will only be evaluated as part of the system (through retroreflectivity readings). Testing of the coatings, gradation and initial quality of the product applied shall be the responsibility of the contractor.

EQUIPMENT

The Contractor's striper shall be equipped with electrical foot counters. The counters shall individually tabulate the amount of footage applied by each striping gun on the carriage, whether solid or dashed. The counters shall be capable of measuring up to six digits and shall have a reset feature. The counters shall be calibrated in the presence of the Engineer to insure an accurate measurement of the paint applied.

The Contractor's striper shall be equipped with an accurate dashing mechanism, capable of being adjusted to retrace existing lane line or centerline markings as directed by the Engineer. The striper shall also be equipped with a detection device that will automatically cutoff the paint guns when a raised pavement marker is detected in the pavement. The Contractor, at their own expense, shall replace or adequately clean any pavement marker lens that is painted.

The Contractor's striper shall be equipped with a **Data Logger System**. The Data Logger shall read the volume of paint consumed in line. Flow may be measured by counting strokes of high pressure airless pumps, or by counting strokes of low pressure pumps. From the footage data and flow data, the data logger shall calculate, in real time, the gallons per mile of each color of paint. It shall also calculate the average wet film thickness for each color. Up to four stroke counters can be used, two for each color. The Data Logger shall read and display the ambient temperature and also the paint temperature of each of the two colors of paint. The data shall be recorded at the beginning of each job and at a minimum of 1 mile increments and the accumulated daily usage and shall be stored for later printing. The Data Logger shall be capable of storing and supplying the necessary scaling and calibration parameters to the flow meters, and shall provide a means of adjusting the calibration factor as necessary. The Data Logger shall include a remote cab mounted display, which shall indicate gallons per mile of actual application and of film thickness. In addition the Contractor's striper shall also be equipped with a calibrated measuring device for measuring material in the striper tanks.

The Contractor shall provide a separate sweeping unit powerful enough to remove normal highway dirt and debris. This unit shall not be a part of the striping truck. All surfaces shall be swept prior to painting and far enough in advance of the striper so as not to cause dust to mix with the paint. Where, in the opinion of the Engineer, abnormal amounts of material have accumulated beyond the capability of the required sweeping unit which will require shoveling or other means to remove, the Engineer will make arrangements, prior to painting, to have the material removed by the Department or that section of roadway will be deleted from the contract.

If quality problems persist, the Engineer may require the Contractor to provide detailed operating instructions from the manufacturer of the striping equipment. The Contractor shall then be required to operate the striping equipment within the suggested operating guidelines of the manufacturer, with particular emphasis on the speed of the striping operation, or make other adjustments until the quality of the striping is satisfactory to the Engineer.

APPLICATION OF STRIPING

All pavement markings shall be installed in accordance with Part III of the MUTCD and these specifications. Roadways shall be marked with 4", 6", 8" and 12" lines as indicated in the plans. The four-inch line shall not be less than four inches nor more than five inches in width. The six-inch line shall not be less than six inches nor more than seven inches in width. All of the Interstate and Parkway system shall be marked with six-inch lines. Gore area markings shall be installed at twice the width of the normal line width on that portion of roadway. All lines shall have distinct, clean edges with proper bead distribution across the entire width and length of the line.

Passing zones and lane lines shall be installed as a 10' segment of paint with a 30' gap. The length of the 10' segment shall not be less than 10' nor longer than 10 feet 6 inches. The stripe-gap cycle shall not be less than 39 feet 6 inches nor longer than 40 feet 6 inches.

Paint shall be applied at a minimum rate of 16.5 gallons per mile of solid four-inch line and 24.8 gallons per mile of solid six-inch line to produce a minimum thickness of 15 mils. Glass beads shall be applied at a minimum rate of six pounds per gallon of paint.

If the Engineer determines that the quality of the striping applied by the Contractor is unsatisfactory with regard to retroreflectivity, bead distribution, paint thickness, overspray, accuracy of retracing, line width, consistency, tracking, etc., he may stop the striping operation immediately until the Contractor can demonstrate that the problem has been corrected. Substantial quantities of poor quality striping, as determined by the Engineer, shall be considered a "striping error" and shall be handled as below.

Any striping error that requires removal of a line applied by the Contractor shall be removed, at the Contractor's expense, by a removal method approved by the Engineer. This removal process shall be done in a manner that shall not be detrimental to the

pavement. Painting over the line with bituminous or other materials to obliterate the markings will not be allowed. Upon notification of a striping error by the Engineer, the Contractor shall be required to begin the process of correcting the striping error within five working days and shall work continuously to complete the corrective work prior to striping any other section of roadway included in this contract. Liquidated damages, as outlined in the Standard Specifications, shall apply for each day beyond the five working days that the Contractor has not begun to correct the striping error or continuously worked to complete the corrective work.

The Contractor shall be responsible for the appropriate disposal of all paint containers, waste products, etc. The Contractor shall also be responsible for all necessary cleanup of any paint or other material that is spilled onto the pavement or elsewhere as a result of his operations.

The Contractor shall be responsible for protecting the line from traffic until dry to eliminate tracking. For the purposes of measuring retroreflectivity, the occasional incidence of tracking will be handled in accordance with KM 202. However, retroreflectivity readings will be taken on sections with substantial amounts of tracking and the readings will be used in the calculation of payment. If the contractor elects to use additional trail vehicles beyond what is specified in the TRAFFIC CONTROL PLAN, the additional cost shall be incidental to the bid item "Maintain and Control Traffic."

PAINT ON VEHICLES

The Contractor shall be responsible for addressing disputes with the public regarding paint on vehicles that occur as a result of his operations. All complaints from the public shall be addressed in a timely manner and the Contractor must demonstrate a "good faith" attempt to resolve disputes to the satisfaction of the citizen. However, the Contractor shall have the right to dispute fault and refuse settlement in cases where the Contractor feels that paint on the vehicle was a result of negligence on the part of the citizen. Unresolved disputes involving paint on vehicles shall be handled through the legal system. The Department shall not be held responsible for paint on vehicles under any circumstances.

RETROREFLECTIVITY REQUIREMENTS

Although the paint used on this project will be tested by the Department for various compositional requirements and minimum acceptable application rates for paint and beads are specified elsewhere in this proposal, it shall be the responsibility of the Contractor to insure that all striping meets the retroreflectivity requirements specified in this contract.

Retroreflectivity readings will be taken only by qualified employees of the Department and Contractor who hold qualification from the Department as Pavement Marking Inspection Technicians or by a Department approved vendor. Portable readings will be taken in accordance with KM202.

The Department may choose to obtain retroreflectivity readings using a mobile retroreflectometer. Mobile retroreflectometer readings will be taken using a 30M-geometry instrument by a Department approved vendor in accordance with KM203.

The minimum retroreflectivity values are as follows:

Minimum Retroreflectivity Values		
Color	Yellow –mcd/m ² /lux	White – mcd/m ² /lux
LTL 2000	175	250
Mobile (30M-geometry)	150	225

The retroreflectivity values listed in this contract have been established taking into account the variances of the retroreflectivity measuring instruments. Therefore, no adjustments for variances will be made when using the measured retroreflectivity readings to determine acceptance or incentive payment.

Restriping will be required for striping that fails to meet the minimum retroreflectivity requirements. The provisions for restriping are described in the section of this contract entitled MEASUREMENT AND PAYMENT. Complete restriping within 30 calendar days after notification by the Engineer except that no striping will be performed after **October 15, 2003**. All aspects of this specification shall apply to lines that are repainted due to failure to meet the requirements of this specification including the retroreflectivity requirements.

Liquidated damages, as outlined in the Standard Specifications, shall be assessed for each day beyond the 30 calendar days that repainting is not completed and shall accrue until the **October 15, 2003** deadline. At that point, no additional striping will be performed and payment will be based upon the Payment Schedule.

SCHEDULING AND PRIORITY PAINTING

The contractor shall begin painting no later than **May 1, 2003**. At the Pre-construction conference, the Engineer may provide the contractor with a list of priority routes (not to exceed 10 percent of the total project estimate) which are to be painted prior to **June 1, 2003**. The painting of all scheduled routes shall be completed by **September 1, 2003**. The Contractor shall be assessed liquidated damages as outlined in Section 108.09 of the Standard Specifications for each calendar day that any of the scheduled routes are not painted with all lines.

The Contractor shall coordinate the daily striping schedule, in advance, with the

Engineer. Once priority routes (if any) are finished, work must be completed in a county, per color, prior to advancing elsewhere except when approved in writing by the Engineer. The Engineer may require the Contractor to prepare a written striping schedule for the entire project, taking into account the priority routes. If required, this schedule shall be presented to the Engineer prior to the commencement of work and shall be updated each week. If a written schedule is not required initially, the Engineer reserves the right to require that a written schedule be provided at any point during the execution of this contract. Also, the Contractor shall be accessible to the Engineer for the purposes of monitoring the Contractor's quality control, traffic control, and obtaining paint samples.

The Engineer may eliminate any route from the schedule if it is determined that the route does not require painting. Also, the Engineer may add additional routes deemed necessary to be painted.

MEASUREMENT AND PAYMENT

The Contractor will be paid for the actual linear miles (rounded to the nearest hundredth) of four-inch and six-inch solid line for each color applied, as determined by the Engineer. Payment for lines other than four-inch and six-inch in width shall be as follows:

8" LINES _____ 2.0 x RATE FOR 4" LINES

12" LINES _____ 2.0 x RATE FOR 6" LINES

Full payment to the Contractor for the bid item 4" and 6" PAVE STRIPING WB (COLOR) will be based upon successful compliance with the retroreflectivity requirements outlined in this proposal. The Contractor will be paid 60% of the payment for the bid item after application of striping to a particular section of roadway. The remaining payment will be made based upon the following procedure and the Payment Schedule:

The work completed in one day by one striping crew for each color will be considered a section. Each section will be divided into segments (according to KM 202 or KM 203) for the purpose of evaluating retroreflectivity.

1. If 80% or more of the readings taken within a segment are above the specified minimum retroreflectivity for each color, the segment will be considered as passing.
2. If a section is not accepted and less than 60% of the readings are above the specified minimum the contractor will be required to restripe. The restriping will be subject to the same requirements as the original striping.
3. If a section is not accepted and the number of passing readings is $\geq 60\%$ and $< 80\%$, the Contractor will be asked to restripe failing segments. The Contractor has the following options:

- Restripe segment at no additional cost to the Department; or
- If time does not allow for the segments to be restriped, accept deduction in payment for striping that has been determined below standard with the understanding that the Contractor may forfeit the incentive monies.

Payment Schedule

	Initial Payment	Final Payment	Total Payment
Passing	60%	40%	100%
Below Standard w/ deduction	60%	20%	80%
Failing	60%	0%	60%

Payment will not be made nor will retroreflectivity tests be conducted for lines that do not meet the minimum application rates for paint and beads. The contractor shall restripe these lines at his expense.

A deduction in payment will be made for using paint that fails to meet the required material composition requirements as outlined in the MATERIALS section of this specification.

INCENTIVE PAYMENT

The Contractor will be eligible for incentive payment based on the retroreflectivity for each color for the entire contract and the following requirements:

- all striping on the routes listed in the bid proposal, including any adjustments provided at the Pre-construction conference, is completed prior to the completion date of **September 1, 2003**;
- at least 95% of the total line miles striped under this contract shall be considered passing as defined in the measurement and payment section of this contract; and
- exceptional retroreflectivity has been achieved as defined in the table below.

Exceptional Retroreflectivity		
Yellow	LTL 2000	> 225
	Mobile	> 200
White	LTL 2000	> 300
	Mobile	> 275

The Department will calculate the incentive payment by multiplying the payment for the total line miles striped for each color by the appropriate Pay Value listed in the "Exceptional Retroreflectivity Adjustment Schedule" below:

Exceptional Retroreflectivity Adjustment Schedule

<u>Percent of Readings in Exceptional Category</u>	<u>Pay Value</u>
25 – 29	+0.05
30 – 34	+0.06
35 – 39	+0.07
40 – 44	+0.08
45 – 49	+0.09
≥ 50	+0.10

Incentive pay for each color will be calculated separately depending on the method by which the retroreflectivity readings were obtained (LTL 2000 or mobile readings). The retroreflectivity readings taken on lines that are restriped will replace the readings obtained on the initial striping for the purposes of calculating the incentive.

TRAFFIC CONTROL PLAN

Waterborne Paint Striping

1. Traffic shall be maintained in accordance with the MUTCD, the Standard Specifications for Road and Bridge Construction, and the Standard Drawings, current editions.
2. Contrary to Section 112 of the Standard Specifications, all items necessary to maintain and control traffic shall be included in the bid item "Maintain and Control Traffic."
3. Any temporary traffic control items, devices, materials, and incidentals shall remain the property of the Contractor, unless otherwise addressed, when no longer needed.
4. The Engineer will approve all signing before the Contractor can start work.
5. If the Contractor desires to deviate from the traffic control scheme outlined in the standard drawings, he shall prepare an alternate plan and present it in writing to the Engineer. This alternate plan can be used only after review and approval of the District and the Divisions of Traffic and Construction.

6. The Contractor's vehicles shall always move with and not across or against the flow of traffic. These vehicles will not be permitted to make U-turns at any location. The striper will not be permitted to stop and back down the road or ramps to stripe gore lines and turn lanes. Vehicles shall enter or leave work areas in a manner that will not be hazardous to, or interfere with, normal traffic flow. Vehicles shall not park or stop except within designated work areas. Personal vehicles will not be permitted to park within the right-of-way except in specific areas designated by the Engineer.
7. The paint supply truck shall not be allowed to operate as one of the traffic control vehicles shown on the standard drawings. If one of the required traffic control vehicles experiences mechanical problems or for some other reason is not available to remain in position as shown in the traffic control scheme, the striping operation shall cease until all required vehicles are in place.
8. Striping may not be permitted on any roadway during the peak times of the day, holiday periods, or special events as determined by the Engineer.
9. On two-lane, two-way highways, the Contractor shall make provisions to the satisfaction of the Engineer to periodically allow traffic to safely pass the train of vehicles in the striping operation.
10. In low speed, urban situations, the intermediate trail vehicle, shown between the striper and the final trail vehicle on the attached traffic control drawings, may be deleted at the discretion of the engineer.

EXTENSION OF CONTRACT

- This contract may be extended for additional one year periods provided both the Department and the Contractor agree to exercise this option. The contract may be extended in one year increments for a total of two additional years after completion of the initial contract. The Department will initiate the offer to extend the contract after the completion of all striping and a review of the Contractor's performance from the prior year.

If extended, the following new provisions will be included in the extended contract:

- Unit bid prices will remain the same for each year this contract is extended.
- The datalogger reporting will be used as a quality control measure to ensure consistent application of striping
- Quantities to be striped in the extended year may be reduced as a result of the durability of the previous striping year.

CONTRACT EXPIRATION

This contract will expire on **December 31 of the calendar year of the contract**, unless an extension of contract has been approved and processed for an additional one-year period.

SAMPLING MANUAL 2005

(CHEMISTRY)

THERMOPLASTIC (SCREED EXTRUDED)

- A. **SAMPLING FREQUENCY:** Obtain manufacturers certification indicating compliance with project special notes or specifications. Obtain a minimum of one sample per batch, per color of material delivered to the project for use. **SMALL QUANTITY** - May allow the use of material contained in the KYTC's List of Approved Materials based on Manufacturers Certification, if total project quantity does not exceed 250 pounds.
- B. **SAMPLE METHOD:**
 - 1. Ensure each bag of material is clearly labeled with the manufacturers' lot number.
 - 2. Obtain unopened bags of material to meet the sampling frequency.
- C. **FUNCTION OF THE RESIDENT ENGINEER:**
 - 1. Check the KYTC's List of Approved Materials to determine if the manufacturer is approved to supply material to the project.
 - 2. Review certificate of compliance to verify that the material meets specification requirements.
 - 3. Obtain a sample as detailed in B.
 - 4. Enter the appropriate information in KMIMS. The KMIMS inspection type for this sample is Prj_Acpt. The KMIMS inspection type for Small Quantities is Certify.
 - 5. Do not allow the contractor to apply material that has not been tested and approved by the Division.
- D. **FUNCTION OF THE DISTRICT MATERIALS ENGINEER:** None
- E. **REMARKS:** Any material delivered to the project without legible manufacturers labeling and lot number should be rejected by the Engineer. Any material that exhibits unsatisfactory application properties; requires excessive heating, discoloration, low bond strength, excessive cracking, should be rejected by the Engineer.

SAMPLING MANUAL 2005

(CHEMISTRY)

THERMOPLASTIC (SCREED EXTRUDED)

- A. **SAMPLING FREQUENCY:** Obtain manufacturers certification indicating compliance with project special notes or specifications. Obtain a minimum of one sample per batch, per color of material delivered to the project for use. **SMALL QUANTITY** - May allow the use of material contained in the KYTC's List of Approved Materials based on Manufacturers Certification, if total project quantity does not exceed 250 pounds.
- B. **SAMPLE METHOD:**
 - 1. Ensure each bag of material is clearly labeled with the manufacturers' lot number.
 - 2. Obtain unopened bags of material to meet the sampling frequency.
- C. **FUNCTION OF THE RESIDENT ENGINEER:**
 - 1. Check the KYTC's List of Approved Materials to determine if the manufacturer is approved to supply material to the project.
 - 2. Review certificate of compliance to verify that the material meets specification requirements.
 - 3. Obtain a sample as detailed in B.
 - 4. Enter the appropriate information in KMIMS. The KMIMS inspection type for this sample is Prj_Acpt. The KMIMS inspection type for Small Quantities is Certify.
 - 5. Do not allow the contractor to apply material that has not been tested and approved by the Division.
- D. **FUNCTION OF THE DISTRICT MATERIALS ENGINEER:** None
- E. **REMARKS:** Any material delivered to the project without legible manufacturers labeling and lot number should be rejected by the Engineer. Any material that exhibits unsatisfactory application properties; requires excessive heating, discoloration, low bond strength, excessive cracking, should be rejected by the Engineer.

MATERIALS

&

KENTUCKY METHODS

MATERIALS HANDLING & KENTUCKY METHODS

- u Resurfacing & Rehabilitation Work
- u District Contract Striping

- ### Resurfacing & Rehabilitation Work
- u Beads are part of the line
 - u Randomly sample paint from striper (minimum once per project)
 - u Sample one bag of thermoplastic per batch per color for quantities over 250 pounds

District Contract Striping

- u State inspectors obtain random paint samples from the stripers on a weekly basis
- Completion of materials evaluation is required prior to initial payment to the contractor

District Contract Striping

- u Beads are evaluated as part of the line
- No sampling or certification required

Kentucky Methods for Pavement Marking Inspection

KM 201
KM 202
&
KM 203

KM 201

LTL INSPECTION OF INTERSECTION MARKINGS

Summary Of Specification

- u Perform a visual inspection and bond checks
- u Perform retroreflectivity tests at each intersection
- u Each marking is considered separately

EVALUATION SPECIFICATIONS

- u 180 day proving period...
- u Evaluate between 30 and 60 days after the date the material is applied for retroreflectivity

PERFORMANCE REQUIREMENTS

- u If all readings taken in an intersection meet or exceed the minimum requirements markings are accepted
- u If any reading fails to meet the minimum requirements additional readings will be taken

ADDITIONAL READINGS

- u These are taken at the discretion of the engineer to assess which markings need to be replaced or repaired

REPORTING

- u Include
 - LTL printout of readings taken
 - Date and time of application
 - From contractor's DSR
 - Location of test
 - County, intersection and markings tested

KM 202

u LTL INSPECTION OF MARKINGS



DEFINITIONS

u Section

- Portion of striping completed by one striping crew in one day

u Segment

- Portion equal to one fifth (or more) of the day's striping

DEFINITIONS CONT.

u Zone

- Location within a segment where one begins taking readings

DIVIDE EACH DAY
ACCORDING TO THE STRIPING
COMPLETED

- u \geq 30 Miles
 - Requires 5 segments
- u \geq 10 Miles and $<$ 30 Miles
 - Requires 3 segments
- u $<$ 10 miles
 - Requires 1 segment

THE ZONE....

- u Randomly generate the starting point of a zone within each segment
 - Mark the beginning & ending of each zone with spray paint
- u Obtain 20 readings within the zone to represent the segment

PASS/FAIL SEGMENTS

- u IF:
 - 80% or more of the readings within a zone pass/the segment passes
- u IF:
 - Less than 80% of the readings pass/additional readings must be taken

Additional Readings!!!

- Establish two additional zones within the segment
- Take twenty readings in each of the two additional zones
- **If:** 80% or more of all readings in the segment pass/ the segment passes

EXCEPTION....

- If 13 or more of the readings in the first zone in a segment fail, additional readings are unnecessary.

- The segment fails

IF:

- 80% or more of all readings in the segment pass
 - The segment passes
- Less than 80% pass
 - The segment is not accepted

IF:

- 3 segments fail (section ≥ 30 miles)
 - The section is not accepted
- 1 segment fails (section < 30 miles)
 - The section is not accepted

REPORTING

- Include
 - LTL printout of readings taken
 - Date and time of application
 - From contractor's DSR
 - Location of test

KM 203

MOBILE INSPECTION OF MARKINGS

DEFINITIONS

- u Section
 - Portion of striping completed by one striping crew in one day
- u Segment
 - Equal to mobile readings taken and averaged over one-tenth of a mile

AT LEAST 50% OF ALL
SEGMENTS IN EACH
SECTION WILL BE
EVALUATED BY THE
MOBILE

PASS/FAIL SECTIONS

PASS/FAIL CRITERIA

- u IF:
 - 80% OR MORE OF THE READINGS FOR A SECTION PASS/THE SECTION PASSES
- u IF:
 - LESS THAN 80% OF THE READINGS PASS/THE SECTION WILL NOT BE ACCEPTED



REPORTING

INCLUDE:

- MOBILE READINGS WHICH WILL INCLUDE DATE AND TIME OF TEST AND CALIBRATION INFORMATION
- DATE OF APPLICATION OF MARKINGS
 - FROM CONTRACTOR'S DSR
- LOCATION OF TEST

QUESTIONS????



Kentucky Method 64-201-03
Dated 2/5/03
Supersedes KM 64-201-00
Dated 7/31/00

EVALUATION OF RETROREFLECTIVITY ON INTERSECTION PAVEMENT MARKINGS USING PORTABLE HAND-OPERATED INSTRUMENTS

1. SCOPE:
 - 1.1. This method covers the evaluation of retroreflectivity on pavement markings using portable hand-operated instruments.
 - 1.2. It is intended to provide standards of intersection pavement markings to assure that adequate retroreflectivity for the driver is provided by newly applied markings.
 - 1.3. Thermoplastic intersection pavement markings will be evaluated in a period of not less than 30 to no more than 60 days after the date the materials are applied.
2. TERMINOLOGY: Retroreflectivity: a standard of measure for pavement markings. The units for these readings are millicandelas per square meter per lux ($\text{mcd}/\text{m}^2/\text{lx}$).
3. SUMMARY OF SPECIFICATION:
 - 3.1. Perform a visual inspection and bond checks for each marking.
 - 3.2. Perform retroreflectivity tests at each intersection on at least 2 markings.
 - 3.3. For the purpose of evaluating retroreflectivity, each marking will be considered separately with 2 readings taken on each marking evaluated. Readings will not be taken on portions of the marking that are in the wheel track or where build up of road debris such as oil, grease, etc. would provide readings not representative of the quality of the work.
4. PERFORMANCE REQUIREMENTS:
 - 4.1. Retroreflectivity: The pavement marking will be evaluated for acceptance within the time period detailed in section 1.3.
 - 4.2. If all four readings taken in an intersection meet or exceed the required minimum retroreflectivity values established for the materials that are being measured, the intersection markings that are being evaluated will be accepted.
 - 4.3. If any of the readings taken in an intersection are below the required minimum retroreflectivity values established for the materials that are being measured, additional readings will be taken within the intersection that is being evaluated.

- 4.4. Taking additional readings: At the discretion of the engineer, additional readings may be taken to assess which markings within an intersection need to be replaced or repaired.

5. REPORTING:

- 5.1. Include the following in the inspection report:

5.1.1. Printout of the readings taken with the hand-operated instrument (which should show date and time of test and zero reading and calibration).

5.1.2. Date and time of application of the pavement marking from the Contractors Daily Report.

5.1.3. Location (County, intersection, marking tested and any special information).

- 5.2. Readings shall be recorded in millicandelas per square meter per lux (mcd/m²/lx).

- 5.3. Measurement shall be reported for each intersection of markings per day.

APPROVED _____
Director
DIVISION OF MATERIALS

DATE 2/5/03

Kentucky Method 64-201-03
Dated 2/5/03
Supersedes KM 64-201-00
Dated 7/31/00

km20103.doc

Kentucky Method 64-202-2002
Revised 12/23/02
Supersedes KM 64-202-2001
Dated 1/3/01

EVALUATION OF RETROREFLECTIVITY ON PAVEMENT MARKINGS USING PORTABLE HAND-OPERATED INSTRUMENTS

1. SCOPE:

- 1.1. This method covers the evaluation of retroreflectivity on pavement markings using portable hand-operated instruments.
- 1.2. It is intended to provide standards of horizontal pavement markings to assure that adequate retroreflectivity for the driver is provided by newly applied markings.
- 1.3. Waterborne pavement markings will be evaluated in a period of not less than 30 to no more than 60 days after the date the materials are applied.
- 1.4. Durable pavement markings such as Thermoplastic, Permanent Pavement Tapes, and Epoxies will be evaluated in a period of time not less than 150 days to no more than 210 days after the date the materials are applied.

2. TERMINOLOGY:

- 2.1. Section: a portion of striping completed by one striping crew in one day.
- 2.2. Segment: a portion equal to one fifth (or more) of the day's striping.
- 2.3. Zone: a location in each segment where one begins taking retroreflectivity readings.
- 2.4. Retroreflectivity: a standard of measure for pavement markings. The units for these readings are millicandelas per square meter per lux ($\text{mcd}/\text{m}^2/\text{lx}$).

3. SUMMARY OF SPECIFICATION:

- 3.1. For the purpose of evaluating retroreflectivity, the work completed in a single day by each crew will be evaluated separately as a section. Divide each section into segments containing a zone (as shown in Figure 1A, Figure 1B, Figure 1C, and as described in Step 3.2). Establish five segments to collect readings to represent a day's striping if the total day's striping is ≥ 30 miles. Establish three segments to collect readings to represent a day's striping if the total day's striping is ≥ 10 miles and < 30 miles. If the total day's striping is < 10 miles the day will be considered one segment.

Figure 1A. Striping Day (≥ 30 miles)

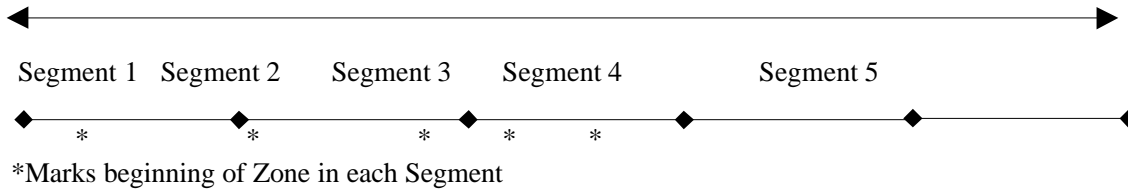


Figure 1B. Striping Day (≥ 10 miles and < 30 miles)

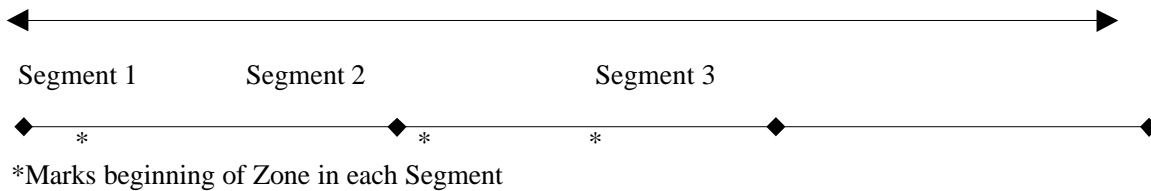
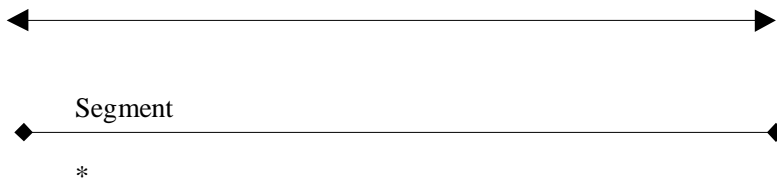
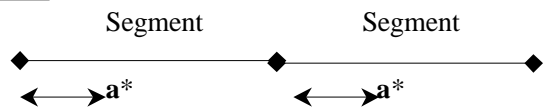


Figure 1C. Striping Day (< 10 miles)



- 3.2. As stated in Step 3.1, divide the number of miles striped in a day to establish the length of each segment. In the first segment, randomly generate a milepoint (to the nearest tenth of a mile) to begin taking readings in the first zone. The distance from the beginning of the segment to the beginning of the zone (distance a^*), in the first zone, will be used to establish the location of each successive zone within successive segments (See Figure 2).

Figure 2.



NOTE: a^* =distance each time, from beginning of each segment, to beginning of zone.

- 3.3. Mark the beginning and ending point of each zone with spray paint. Zero and calibrate the hand-operated instrument. Print the zero and calibration readings at the beginning of the days work. Recalibrate the instrument every 2 hours when taking readings. Print the zero and calibration readings each time these operations are performed.
 - 3.4. Take 20 readings in each of the zones. Take the first reading exactly at the beginning of the zone. Take subsequent readings at approximately 15-foot intervals (5 paces). If any portion of the zone is unsafe for taking readings, move forward to the first point which can be inspected safely and begin the zone there. Do not move the zone simply for convenience. A change in the starting point of one zone should not change the starting points of any subsequent zones. Also, if a valid reading is not attainable at a location within the zone due to a pothole, grass, obvious tracking, etc., move forward in the zone to the first available location for a valid reading, then resume the subsequent readings within that zone in the incremental procedure described above. For readings taken on centerlines, take alternating readings between solid lines or on the combination of solid and skip lines.
 - 3.5. When a zone contains only skip lines for evaluation. Measure each skip line at two evenly spaced locations on the line. Continue measuring within the established zone in this manner until 20 readings are obtained.
4. PERFORMANCE REQUIREMENTS:
- 4.1. Retroreflectivity: The pavement marking will be evaluated for acceptance within the time period detailed in sections 1.3 and 1.4.
 - 4.2. If 80% (16 or more) of the readings in a zone meet or exceed the required minimum retroreflectivity values established for the materials that are being measured, the segment that is being evaluated will be accepted.
 - 4.3. If less than 80% (less than 16) of the readings in a zone meet the required minimum retroreflectivity values established for the materials that are being measured, additional readings will be taken within the segment that is being evaluated.
 - 4.4. Taking additional readings - Randomly establish two (2) new zones within the segment in question using the procedure detailed in section 3.2. Obtain readings for each of these zones as described in 3.2 –3.4. These readings will be combined with the initial readings for evaluation of the segment. If less than 80% of the 60 readings (20 in each of three zones) taken within a segment meet the minimum retroreflectivity requirements established for the materials that are being measured, the segment is not accepted. Alternatively, if 13 or more of the first 20 readings taken within a segment fail to meet the minimum retroreflectivity requirements established for the materials that are being measured, the segment is not accepted and additional testing within that segment is not required.

- 4.5. If three of five segments are not accepted on a section of striping that is ≥ 30 miles in length, the entire section of striping will not be accepted. If one segment is not accepted on a section of striping that is <30 miles in length, the entire section of striping will not be accepted.

5. REPORTING:

- 5.1. Include the following in the inspection report:
- 5.1.1. Printout of the readings taken with the hand-operated instrument (which should show date and time of test and zero reading and calibration)
 - 5.1.2. Date and time of application of the pavement marking from the Contractors Daily Striping Report
 - 5.1.3. Location (County, Route, Milepoint, direction of travel, color of line, and any special information)
- 5.2. Record readings in millicandelas per square meter per lux ($\text{mcd}/\text{m}^2/\text{lx}$).
- 5.3. Report measurements for each section of striping per color per day.

APPROVED _____
Director
DIVISION OF MATERIALS

DATE 12/23/02

Kentucky Method 64-202-2002
Revised 12/23/02
Supersedes KM 64-202-2001
Dated 1/3/01

Km20202.doc

Kentucky Method 64-203-02
Revised 12/26/02
Supersedes 64-203-00
Dated 2/11/00

EVALUATION OF RETROREFLECTIVITY ON PERMANENT PAVEMENT MARKINGS USING MOBILE 30 METER GEOMETRY INSTRUMENTS

1. SCOPE:

- 1.1. This method covers the evaluation of retroreflectivity on permanent pavement markings using mobile 30-meter geometry instruments.
- 1.2. It is intended to provide standards of horizontal pavement markings to assure that adequate retroreflectivity for the driver is provided by newly applied markings.
- 1.3. Waterborne pavement markings will be evaluated in a period of not less than 30 to no more than 60 days after the date the materials are applied.
- 1.4. Durable pavement markings such as Thermoplastic, Permanent Pavement Tapes, and Epoxies will be evaluated in a period of time not less than 150 days to no more than 210 days after the date the materials are applied.

2. TERMINOLOGY:

- 2.1. Section: a portion of markings completed by one striping crew in one day.
- 2.2. Segment: is equal to mobile readings taken and averaged over one-tenth of a mile.
- 2.3. Retroreflectivity: a standard of measure for pavement markings. The units for these readings are millicandelas per square meter per lux ($\text{mcd}/\text{m}^2/\text{lx}$).

3. SUMMARY OF SPECIFICATION:

- 3.1. For the purpose of evaluating retroreflectivity, the work completed in a single day by each crew will be evaluated separately as a section.
- 3.2. Calibrate the mobile instrument. Record calibration readings at the beginning of the day's work. Recalibrate the instrument as necessary when taking readings. Provide the calibration readings in the retroreflectivity report, each time these operations are performed.
- 3.3. The Department will provide the Contractor operating the mobile retroreflectometer with routes for evaluation. The lines evaluated will represent at least 50% of the segments completed in one day of striping. Segments will be randomly selected from the Contractors Daily Striping Report for Mobile Inspection.

4. PERFORMANCE REQUIREMENTS:

KM 64-203-02

- 4.1. Retroreflectivity: The pavement marking will be evaluated for acceptance within the time period detailed in sections 1.3.
- 4.2. If 80% or more of the readings in a section meet or exceed the required minimum retroreflectivity values established for the materials that are being measured, the section will be accepted.
- 4.3. If less than 80% of the readings in a section meet the required minimum retroreflectivity values established for the materials that are being measured, the section will not be accepted.

5. REPORTING:

- 5.1. Include the following in the inspection report:
 - 5.1.1. Readings taken with the mobile retroreflectometer (which should show date and time of test and calibration information).
 - 5.1.2. Date of application of the pavement marking.
 - 5.1.3. Location (County, Route, Milepoint, Intersection, direction of travel, color of line, and any special information).
- 5.2. Readings shall be recorded in millicandelas per square meter per lux (mcd/m²/lx).
- 5.3. Measurement shall be reported for each section of striping per color per day.

APPROVED _____
Director
DIVISION OF MATERIALS

DATE 12/26/02

Kentucky Method 64-203-02
Revised 12/26/02
Supersedes 64-203-00
Dated 2/11/00

Km20302.doc

LTL 2000

DOWNLOAD INSTRUCTIONS

&

INSPECTION SPREADHSEETS

Downloading the stored data.

1. Connect the male end of the data cable to the communications port on the back panel of the LTL 2000 and the female end of the cable into the communication port of the computer.
2. Turn on the computer.
3. Turn on the LTL 2000
4. Click on the Windows Start buttons.
5. Click on Programs à Click on Accessories à Click on HyperTerminal.
6. Double click on the Hypertrm icon. If you already have an LTL 2000 icon, double click on this icon and skip to step 10.
7. Type 'LTL 2000' and select an icon (it doesn't matter which one), then click on OK.
8. Go to the Connect using box and select Direct to Com 1 from the list then click on OK.
9. Set the port settings to; Bits per second – 9600, Data bits – 8, Parity – None, Stop bits – 1, Flow control – Xon/Xoff à click on OK.
10. Click on Transfer à Click on Capture Text.
11. Type in a file name with a drive and folder location. Type a '.txt' at the end of the file name, i.e. 'data1.txt'. Make sure that you remember the file and folder location so you can find it later.
12. Click on Start.
13. Press the Enter key on the computer.
14. Type the command 'LR' and press the Enter key on the computer. This will download the data in a fixed width format. If you want to download the data in a comma delimited format, type the command 'LE' and press the Enter key on the computer.
15. When the downloaded is finished, an asterisk will be displayed after the last line of data (Note: downloading data does not erase the data log memory of the LTL).
16. Click on Transfer à Click on Capture Text à Click on Stop.
17. Click on File à Click on Exit.
18. Click on Yes to disconnect.
19. You may be asked to save the session here. Save this session as a file, then during future download operations, you can skip steps 7 through 10 by double clicking on the icon for LTL 2000.
20. You're done downloading data. The LTL 2000 can be disconnected and turned off.

Importing the data to Excel (for other spreadsheets, please refer to your software manual).

1. Click on Start.
2. Click on Programs.
3. Click on Microsoft Excel.
4. Click on File à Click on Open.
5. Set the drive and folder options to look for your file where your data file is stored (from step 14).
6. Locate your data file by changing the 'List Files of Type' to list Text files (*.txt) in the active directory.
7. Open the file you wish to import by clicking on it and clicking on Open.
8. The Text Import Wizard step 1 of 3 will now appear on your screen. Click on 'Fixed Width'. If you used the 'LE' command in step 14 of the downloading, click on 'Delimited'.
9. Click on the 'Next' button.
10. Make sure that the data is separated by vertical lines in the correct columns in the Data Preview box.
11. Click on the 'Finish' button.

LTL 2000 Data Downloading Instructions for Windows 95/98/NT

12. To save the spreadsheet, click on 'File' and then click 'Save As...'. Change the 'Save as Type' to Microsoft Excel Workbook and type in a name for the file. Then click on Save.

Note 1. Try COM port 1 first. If there is no response to the LE command, try changing the setting to COM port 2.

Trouble Shooting.

If the download operation does not work properly, please check through the following items.

- Is the LTL 2000 turned on?
- Is the data cable connected securely at both end (be sure to check to see if the connector pins on the cable and on the devices are not bent or missing)?
- Are your communications settings correct (See step 11)?
- Is the com port you are attempting to use open and available to the communication software?

If no letters appear on the screen or letters get doubled when you type, please do the following.

- Click on File à Click on Properties à Click on the Settings tab à Click on ASCII Setup...
- Look at the Echo type characters locally option. If it is checked, uncheck it. If it is not checked, check it. Do this by clicking on the box.
- Click on OK à Click on OK.

If you have checked the above items and made sure that everything is set properly and communication with the LTL 2000 still cannot be established, please call Flint Trading, Inc.'s technical support department. They can be reached at (336)475-6600, Monday through Friday, 8am till 5pm, Eastern Standard Time.

WHITE YELLOW

strict _____ Precipitation _____ Temperature AM _____ PM _____ Road Conditions _____

Notes:	CH Number				
	Total lineal feet of stripe				
	Total miles of stripe				
	50% Paid this date				
	MATERIALS USED	QUANTITY	BATCH NO.	LEGEND:	
	PAINT	GAL.		EL=EDGE LINE CL=CENTER LINE	
BEADS	LBS.		SK=SKIP WBL=WESTBND LANE		
			EBL=EASTBND LANE		
			SBL=SOUTHBND LANE		
			NBL=NORHTBND LANE		

INSPECTOR:_____

MOTIF

DATE PAINTED: **FIRST DATE TO TEST:**

*** 50% PAID WHEN
PASSING PAINT
REPORT RECEIVED**

**FAIL:
READINGS ABOVE 225;**

RESIDENT ENGINEER

[illegible]

STRIPING REFLECTIVITY TEST

YELLOW

DATE PAINTED: 08/24/00 FIRST DATE TO TEST: 09/23/00 LAST DATE TO TEST: 10/23/00

TEST SITE:	SEGMENT #1			SEGMENT #2			SEGMENT #3			SEGMENT #4			SEGMENT #5			REFLECTIVITY REQUIREMENTS
ZONE:	#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3	MINIMUM: 175
DATE CHKD:	10/18/2000	10/18/2000	10/18/2000	10/18/2000	10/18/2000	10/18/2000	10/18/2000	10/18/2000	10/18/2000	10/18/2000	10/18/2000	10/18/2000	10/18/2000	10/18/2000	10/18/2000	BONUS: 225
COUNTY:	TRIGG	TRIGG	TRIGG	TRIGG	TRIGG	TRIGG	TRIGG	TRIGG	TRIGG	TRIGG	TRIGG	TRIGG	TRIGG	TRIGG	TRIGG	
ROUTE:	KY 525	KY 525	KY 525	KY 1253	KY 1253	KY 1253	KY 164	KY 164	KY 164	KY 139	KY 139	KY 139	KY 139	KY 139	KY 139	
SEGMENT MP:	3	3	3	1.80	1.80	1.80	18.80	18.80	18.80	0.20	0.20	0.20	8.30	8.30	8.30	
ZONE MP:	5.3	5.3	5.3	4.1	4.1	4.1	21.1	21.1	21.1	2.5	2.5	2.5	10.6	10.6	10.6	10.4
LOCATION:	SCL	SCL	SCL	SCL	SCL	SCL	W CL	W CL	W CL	N CL	N CL	N CL	N CL	N CL	N CL	
READING NO:	READING	READING	READING	READING	READING	READING	READING	READING	READING	READING	READING	READING	READING	READING	READING	LEGEND:
1	66	87	83	120	119	130	217	217	217	228	235	235	104	105	103	These areas were retested with the contractor and found to pass. Pay 100% as directed by John Mark Clements (cig)
2	94	94	83	121	119	111	236	236	236	235	237	237	106	105	105	
3	89	92	83	122	118	134	231	231	231	237	237	237	108	103	104	
4	84	94	87	121	117	133	235	235	235	239	242	242	107	104	109	
5	81	94	90	124	118	122	239	239	239	242	245	245	109	105	100	
6	91	90	91	118	120	123	241	241	241	243	243	243	111	103	103	
7	88	86	84	111	118	120	244	244	244	243	243	243	105	100	103	
8	90	85	92	118	117	123	245	245	245	243	243	243	112	91	98	
9	93	85	93	120	119	127	245	245	245	243	243	243	108	98	105	
10	90	90	90	116	119	126	243	243	243	240	240	240	103	106	105	
11	81	92	90	117	117	124	241	241	241	239	239	239	105	104	103	MILES STRIPED
12	84	85	83	120	116	126	236	236	236	234	234	234	92	107	105	M P
13	88	86	87	121	119	130	236	236	236	235	235	235	105	108	104	CH NO. MILES
14	90	80	88	123	116	126	235	235	235	235	235	235	103	110	103	2231 48,500
15	92	72	94	122	119	129	236	236	236	233	233	233	106	105	102	R S
16	86	82	86	121	126	124	233	233	233	234	234	234	102	107	102	CH NO. MILES
17	82	79	85	124	131	128	232	232	232	235	235	235	100	109	109	2232 13,740
18	84	84	77	123	125	127	231	231	231	237	237	237	107	105	104	
19	85	85	85	120	117	122	231	231	231	238	238	238	103	103	106	* 40% PAID WHEN PASSING PAINT REPORT RECEIVED
20	90	82	85	117	121	129	236	236	236	238	238	238	105	100	107	

0%

0

60

100%

20

100%

20

20

0%

0

60

0%

0

60

0%

FAILS

Initial Pay 60%

CH NO:

2231

2232

MILES:

29,154

8,244

Pay 40% Upon Reflectivity Acceptance

CH NO:

2231

2232

MILES:

19,436

5,496

Number Of Segments Tested

5

Number Of Segments Failed

3

SECTION FAILS

TEST BY: MIKE BUSH

RESIDENT ENGINEER R.C. BURCHETT

SEGMENT LENGTH: 8.1

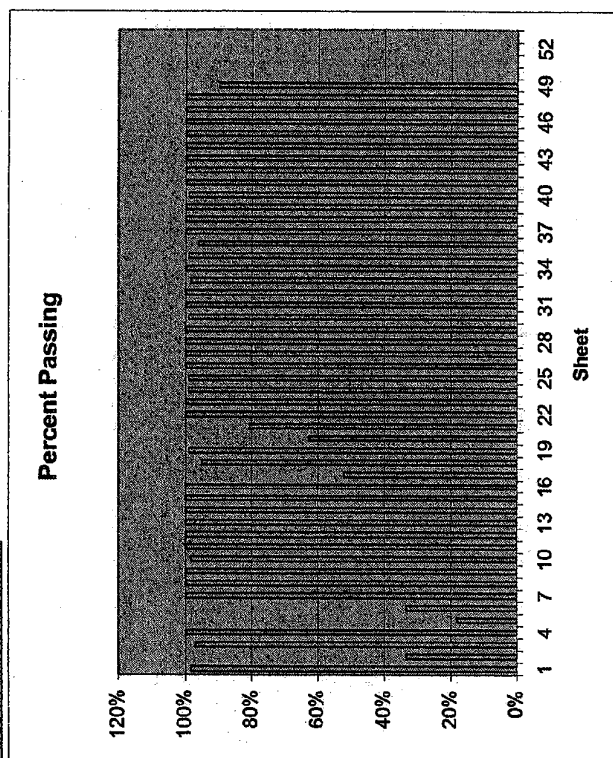
RANDOM INSPECTION #: 2.3

DO NOT MODIFY THIS SHEET IIIIIII

Percent Bonus

Sheet # Percent Passing

1	98%
2	33%
3	97%
4	100%
5	18%
6	33%
7	100%
8	100%
9	100%
10	98%
11	100%
12	100%
13	100%
14	100%
15	100%
16	100%
17	52%
18	95%
19	99%
20	63%
21	81%
22	100%
23	100%
24	99%
25	99%
26	100%
27	100%
28	100%
29	100%
30	99%
31	100%
32	100%
33	98%
34	100%
35	99%
36	96%
37	100%
38	100%
39	100%
40	99%
41	100%
42	100%
43	100%
44	100%
45	100%
46	100%
47	100%
48	100%
49	90%
50	



WHITE

DATE PAINTED:	FIRST DATE TO TEST:	LAST DATE TO TEST:

TEST SITE:	SEGMENT #1			SEGMENT #2			SEGMENT #3			SEGMENT #4			SEGMENT #5			REFLECTIVITY REQUIREMENTS MINIMUM: 250 BONUS: 300
	#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3	
ZONE:																
DATE CHKD:																
COUNTY:																
ROUTE:																
SEGMENT MP:																
ZONE MP:																
LOCATION:																
READING NO	READING	READING	READING	READING	READING	READING	READING	READING	READING	READING	READING	READING	READING	READING	READING	
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
11																
12																
13																
14																
15																
16																
17																
18																
19																
20																
* 50% PAID WHEN PASSING PAINT REPORT RECEIVED																

SEGMENT LENGTH:	8.0	TOTAL READINGS: _____	PASS:	FAIL:
RANDOM INSPECTION #:	4.6			
		TOTAL PAY: 100%		

PAY					
CH NO:					
MILE S:					

TEST BY:

RESIDENT ENGINEER

STRIPING REFLECTIVITY TEST

WHITE

DATE PAINTED: 08/28/00 FIRST DATE TO TEST: 09/27/00 LAST DATE TO TEST: 10/27/00

TEST SITE:			SEGMENT #1			SEGMENT #2			SEGMENT #3			SEGMENT #4			SEGMENT #5			REFLECTIVITY REQUIREMENTS	
#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3	MINIMUM:	BONUS:
10/19/2000			10/19/2000			10/19/2000			10/19/2000			10/19/2000			10/19/2000			250	300
GRAVES			GRAVES			GRAVES			GRAVES			GRAVES			GRAVES				
US 45			US 45			US 45			US 45			US 45			US 45				
ROUTE:			ROUTE:			ROUTE:			ROUTE:			ROUTE:			ROUTE:				
0			0			0			0			0			0				
0.1			0.1			0.1			0.1			0.1			0.1				
SEGMENT MP:			SEGMENT MP:			SEGMENT MP:			SEGMENT MP:			SEGMENT MP:			SEGMENT MP:				
0			0			0			0			0			0				
0.1			0.1			0.1			0.1			0.1			0.1				
LOCATION:			LOCATION:			LOCATION:			LOCATION:			LOCATION:			LOCATION:				
SEL			SEL			SEL			SEL			SEL			SEL				
READING NO	READING	READING	READING NO	READING	READING	READING NO	READING	READING	READING NO	READING	READING	READING NO	READING	READING	READING NO	READING	READING		
1	398		1	369		1	317		1	394		1	430		1	433		EL-EDGE LINE	
2	399		2	365		2	341		2	401		2	414		2	434		CL-CENTERLINE	
3	397		3	374		3	351		3	388		3	407		3	421		WBL-WESTBND LANE	
4	395		4	387		4	345		4	377		4	416		4	430		EBL-EASTBND LANE	
5	401		5	383		5	348		5	368		5	417		5	432		SEL-SOUTHBND LANE	
6	396		6	382		6	343		6	366		6	429		6	446		NBL-NORTHBND LANE	
7	399		7	383		7	340		7	372		7	435		7	448			
8	393		8	371		8	339		8	383		8	433		8	441			
9	394		9	367		9	328		9	388		9	434		9	448			
10	397		10	374		10	322		10	386		10	421		10	447			
11	398		11	375		11	334		11	383		11	430		11	441			
12	398		12	387		12	343		12	388		12	432		12	446			
13	400		13	387		13	347		13	386		13	446		13	448			
14	396		14	378		14	347		14	381		14	448		14	447			
15	395		15	374		15	347		15	372		15	447		15	441			
16	398		16	367		16	350		16	368		16	441		16	439			
17	396		17	364		17	342		17	369		17	439		17	433			
18	389		18	370		18	341		18	378		18	433		18	428			
19	385		19	360		19	340		19	380		19	428		19	422			
20	385		20	363		20	340		20	384		20	422		20				

* 40% PAID WHEN PASSING PAINT REPORT RECEIVED

Number Of Segments Tested
Number Of Segments Failed

5
0

TEST BY: MIKE BUSH

RESIDENT ENGINEER R.C. BORGHEI

Initial Pay 60%

CH NO:	2231
MILES:	26,820
Pay 40% Upon Reflectivity Acceptance	
CH NO:	2231
MILES:	17,880

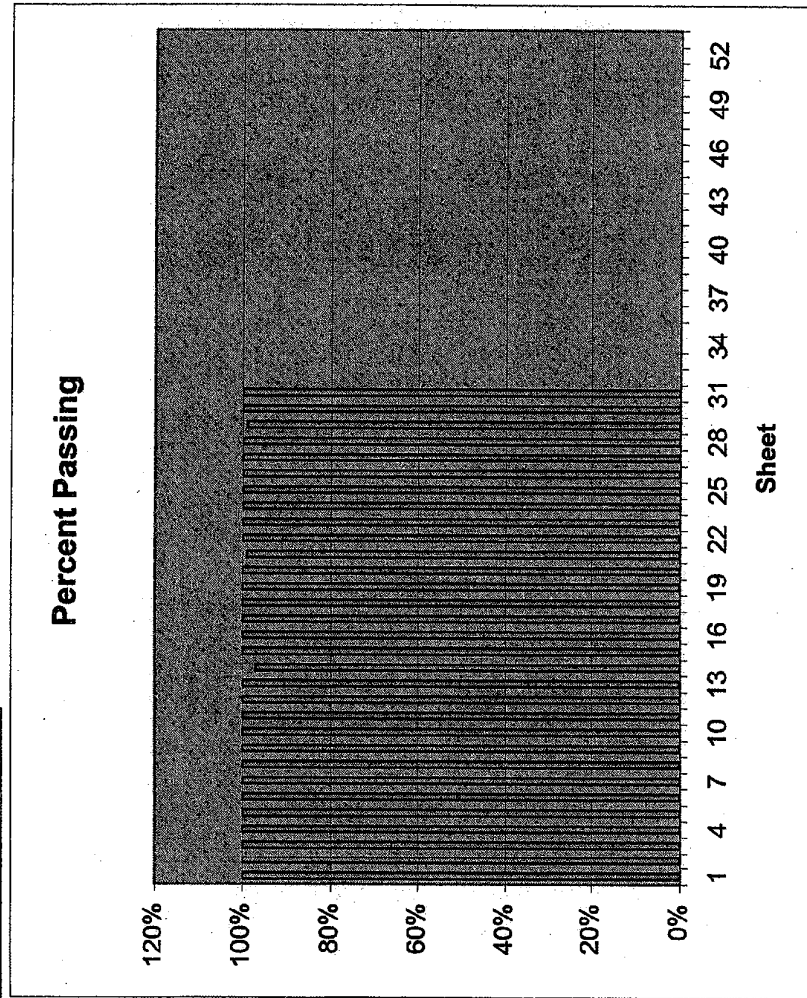
SEGMENT LENGTH: 9.0
RANDOM INSPECTION #: 0.1

DO NOT MODIFY THIS SHEET !!!!!!!

Percent Bonus

Percent Passing

Sheet #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Percent Passing	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	97%	100%	100%	100%	100%	100%	100%	99%	100%	100%	100%	100%	100%	100%	99%	100%	100%



LTL 2000 OVERVIEW

&

HANDS ON

DEMONSTRATIONS



LTL 2000 Training

David Rice
Division of Materials



LTL 2000 Retroreflectometer

Repeatability, Reproducibility
Traceability



Performance/Visibility

n Daytime

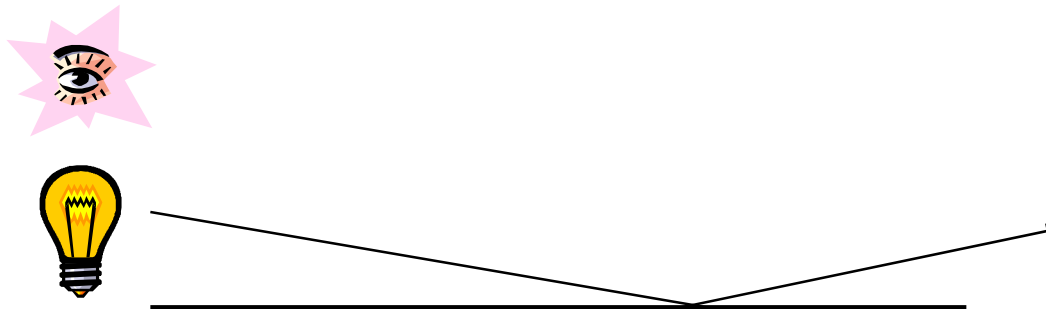
n Nighttime

ê We depend on retroreflection to see pavement markings at night.

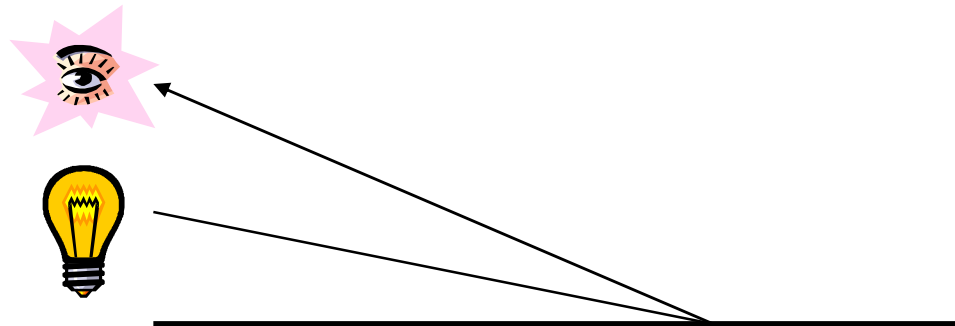


Retroreflection

Light Comes Back Towards The Source



Mirror reflection

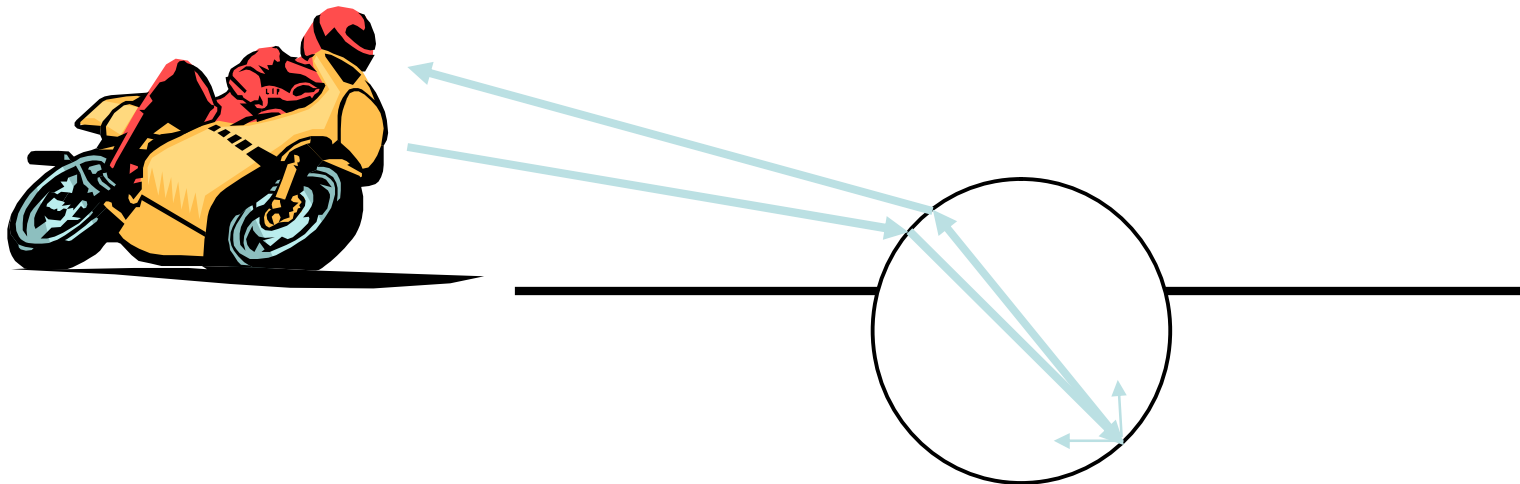


Retro reflection



Retroreflectivity On Markings

Glass beads make it work





Glass Beads

What affects performance?

n Material

- ê Roundness
- ê Clarity
- ê Index of Refraction
- ê Size

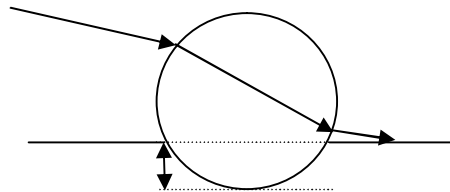
n Application

- ê Embedment
- ê Coverage (Density)

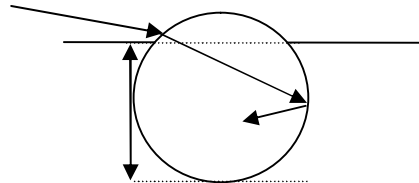


Glass Beads

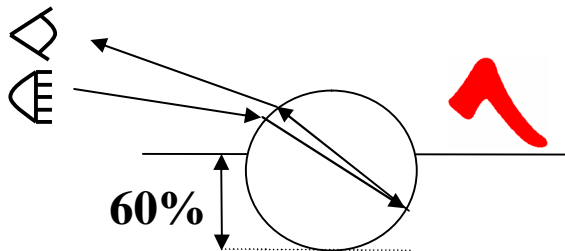
Embedment



High Embedment, Poor



Low Embedment, Poor



60% Embedment, Good



LTL 2000 Retroreflectometer



- n Traceability
- n Repeatability
- n Reproducibility



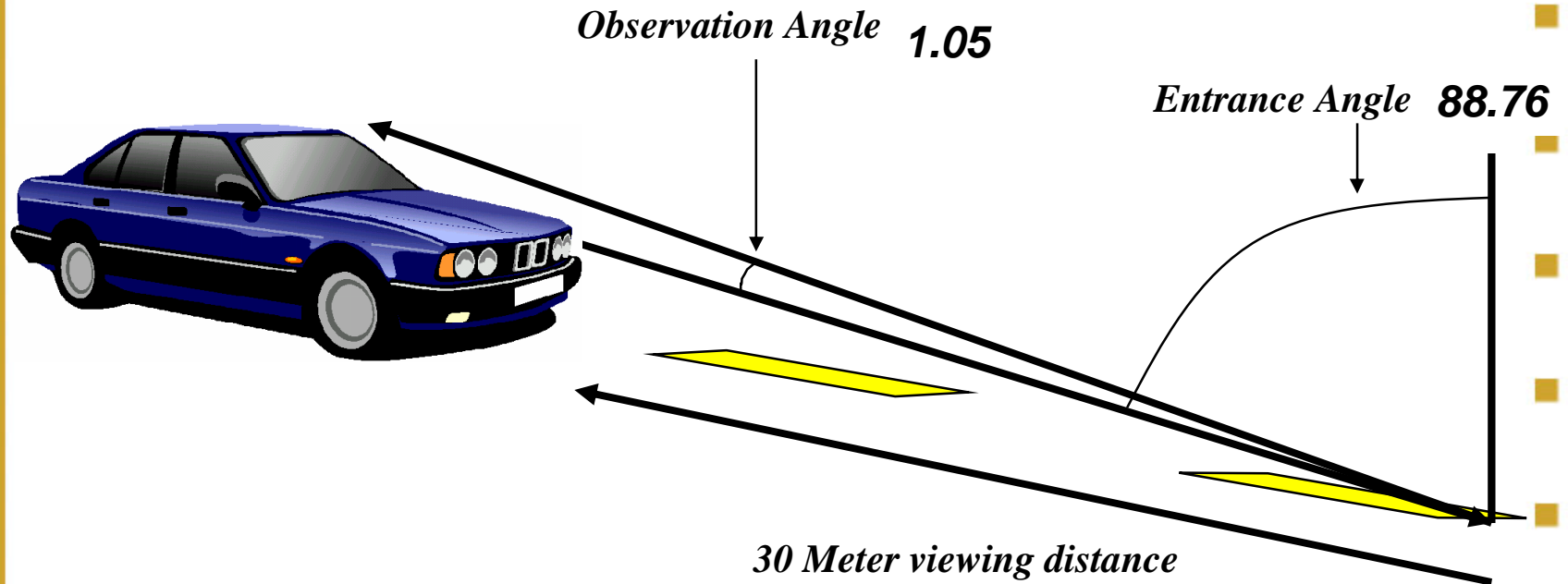
LTL 2000

**30 Meter Geometry
Pavement Marking Retroreflectometer**

Conforms to
ASTM E 1710
CEN EN 1436



Measuring Retroreflectivity with 30 Meter Geometry





Features

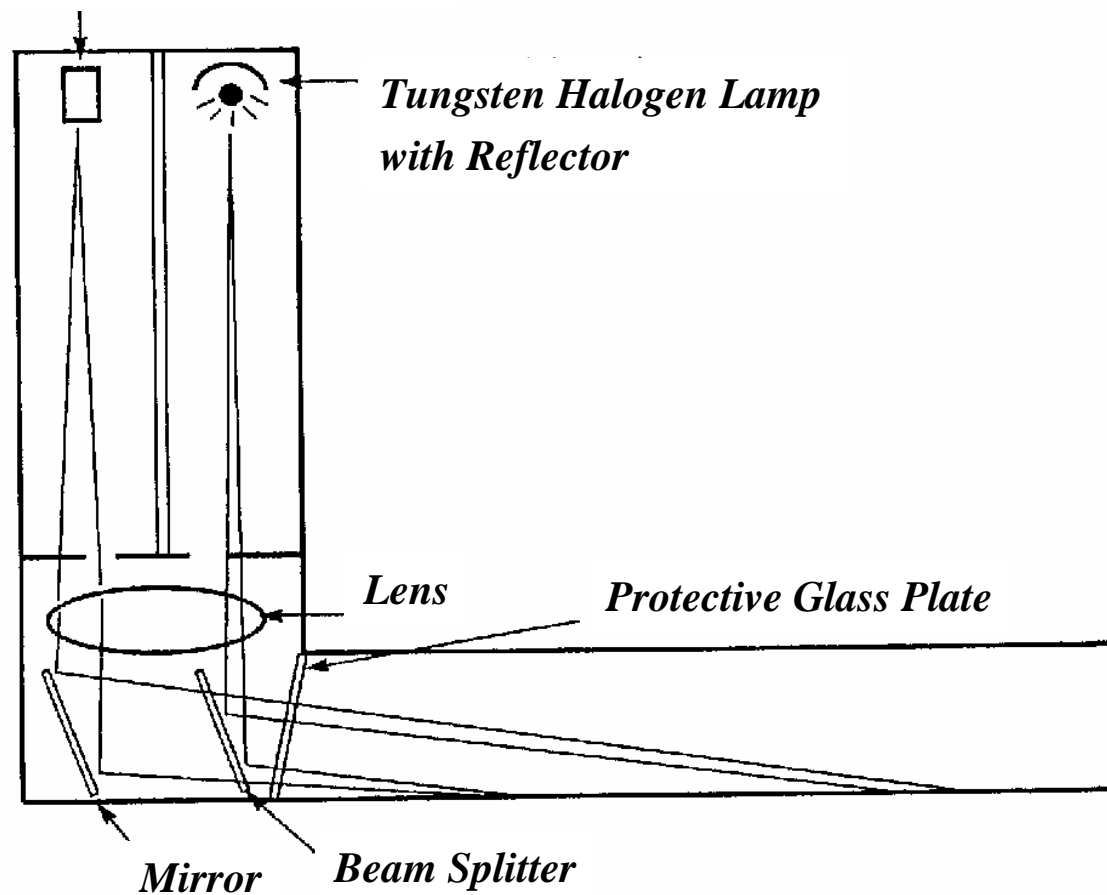
- *Proven, worldwide use*
- *30 meter geometry*
- *Traceable ceramic calibration standard*
- *Repeatable and reliable data*
- *Built-in printer to record measurements*
- *Self-diagnostics with warnings*
- *Stray light compensation*
- *Electronic calibration, No warm up time*
- *Stores 1000 measurements with I.D. labels for down loading to a computer*
- *Type 'A', tungsten halogen light source*



Optical Layout

(not to scale)

Photomultiplier (Receptor)





Instrument Measurement Considerations

Do's

- Check the calibration date (date is not more than 1 week old)
- Make sure that the base frame and instrument are clean
- Make sure the battery is charged
- Make sure the data log has enough space
- Transport the instrument in a non-air-conditioned area of your vehicle

Don'ts

- Take the instrument from a cool or cold area to a warm or hot area without letting it acclimate for 15 minutes



Calibration Block Considerations

Do's

- Store the black block properly inside it's case within the office
- Store the red block in the LTL 2000 storage compartment when not in use

Don'ts

- Leave the calibration blocks out side of their storage compartments
- Touch the white ceramic area of the calibration blocks
- Bump edges of the calibration blocks, this could cause damage to the ceramic area
- Take the black block out side of the office



Pavement Marking Considerations

- *Do's*
 - É *Make sure the markings are dry from application*
 - É *Make sure the markings are dry from moisture*
- *Don'ts*
 - É *Take measurements on wet or damp markings*
 - É *Take measurements on markings with loose glass beads or debris on them*



Environment Considerations

- *Do's*
 - É *Make sure the operating temperature is 32 °F to + 114 °F*
 - É *The humidity should be between 0 and 90% and non-condensing*
- *Don'ts*
 - É *Use the instrument when moisture is condensing out of the air, such as early morning dew*
 - É *Use the instrument too soon after moving it from place to place where the temperature or humidity are very different*



LTL 2000 Accessories

- n Black Laboratory Block
- n Field Block
- n Communications Cable
- n Battery Charger
- n Paper
- n Fuses
- n Calibration Labels



Base and Calibration Blocks





Control Panel





Control Panel Keys

- n **On** – Hold Down for 2 Seconds
- n **Off** – To turn unit off
- n **RL** – Press to take a reading
- n **Calib** – To calibrate the LTL 2000
- n **Enter** – To select an option
- n **Menu** – To enter the menu system
- n **Print** – To print the current reading, Zero, Calibration or Special Test
- n **Up & Down Arrows** – To scroll through options on the display
- n **2nd Test** – To do a special test
- n **2nd Zero** – To do a zero reading
- n **2nd Feed** – To feed out extra paper after the print function
- n **2nd Cancel** – To cancel out of any function you are in



Menu System

n Status Display

- é Last measurement
- é Software copyright date
- é Software version number
- é Free T log
- é Free log
- é Battery voltage
- é Battery voltage under load
- é Battery voltage idle
- é Stray light
- é Signal strength

n Disable the data ID

- n RL log
- n Test log
- n Date & time
- n Set ROM defaults
- n Log warn enable/disable
- n Off time
- n Print RL log



Ready, Get Set, Go!

- *Turn on the LTL 2000*
- *Set zero*
- *Calibrate*
- *Check the calibration*
- *Remove the LTL from the base frame*
- *Take measurements*



When Should You Calibrate?

- *Before the start of work each day*
- *If the LTL 2000 has not been used for 30 minutes or more*
- *Once every 2 hours if the LTL 2000 is being used continuously all day*
- *Keep the traceable calibration block (black block) at the office*



Set Zero Procedure

- n Turn the instrument on.
- n Set Zero
 - é Press 2'nd and zero button at the same time
 - é Press the enter button
 - é Check that zero is OK
 - é Wait for ready status
 - é Press print button



Calibration Procedure

n Calibrate

- é Press the calibrate button
- é Press the enter button
- é Place the calibration block into base frame
- é Press the enter button
- é Make sure the number displayed matches the number on the block.
- é Press the enter button
- é Wait for ready status
- é Press the print button



Checking the Calibration

- n Check the calibration
 - é Press the 2'nd and TEST button at the same time
 - é Make sure that the number displayed matches the number on the block
 - é Recalibrate if necessary
- n Remove the instrument from the base frame
- n You're ready to take measurements



What Can Go Wrong With Calibration

- n Forget to do the zero set
- n Forget to put the calibration block into the base-frame for the calibration step
- n Put the calibration block into the base frame for the zero set
- n Put the calibration block into the base frame facing the wrong way
- n Not doing the calibration



Removing the LTL 2000 from its Base Frame

- n Pull front lever forward slightly past screw on the front of the base frame & lift up on front end
- n Slide LTL 2000 forward so rear two screws are removed from rear holes
- n Lift LTL 2000 up & out of base frame



Procedure for Taking Readings

- n Place the LTL on the marking straight down making sure that the LTL covers the marking as much as possible
- n Moving the LTL on the marking must be done by lifting the LTL straight up, do not slide unit, this can cause damage to the optic window
- n Press the RL button to take a reading



ID Labels

n Steps to create or change the ID label

- é Press the down arrow button with a regular reading on the screen
- é Press the enter button
- é Press the up and down arrow buttons to get desired character (use the 2'nd button to go faster)
- é Press the enter button to move to the next space
- é Press the enter button to finish
(make sure you press the enter button until the last RL reading is displayed, or your ID will not be saved)



How to do a Calibration Transfer

- *Turn on the LTL 2000*
- *Do Set Zero Procedure*
- *Calibrate on the Black Laboratory block*
- *Check the calibration*
- *Measure the Red Field block (RL measurement)*
- *Write down the new value and date on the Red Field block calibration label*



Start of Day / End of Day check out

- n Check the base frame for dust or dirt, clean if necessary
- n Check the Optic window for dust or dirt, clean if necessary
- n Check that the calibration date on the Red field block is not more than 1 week old, if so do a calibration transfer
- n Make sure the battery is fully charged
- n Make sure the data log has enough space for your new readings



On Board Printer



Measurement Readout

0

Zero Measurement

Zero Signal: 0.13% OK

T#: 9 1998 Mar 30 13:57:37 Status: 0

Calibration

RL Normal: 154 mcd·m⁻²·lx⁻¹

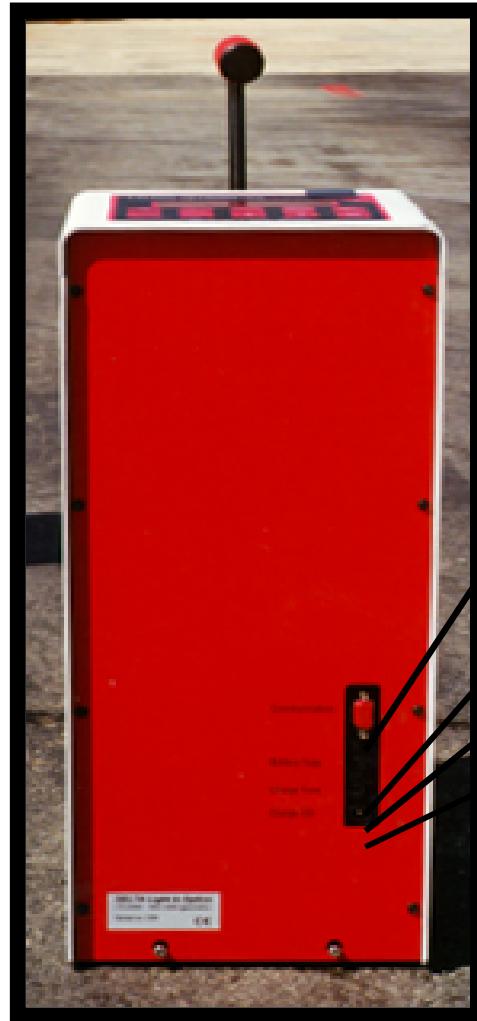
T#: 10 1998 Mar 30 13:58:02 Status: 0

·RL: 376 mcd·m⁻²·lx⁻¹

R#: 64 1998 Mar 30 13:58:36 Status: 0



Back of LTL 2000



Communication port

Battery fuse

Charge fuse

12V charge



Warnings



- * = No problem
- L = Stray light
- W = Low battery or low data log memory
- E = Problem detected
- Search through the status display to find the cause for the error



Keep The Window & Base Frame Clean





Cleaning the LTL 2000

- *Do not clean the black block it is your traceable standard. It can only be certified by Delta Light & Optics.*
- *Clean the Red block with windex & a lint free cloth. After cleaning a calibration transfer needs to be performed*
- *Clean the optic window with windex & a lint free cloth*
- *Use canned air or a lint free cloth to clean the base frame of dirt & dust*
- *Use canned air or a lint free cloth to clean the light trap of dirt & dust*



Charge the battery



- *Charge the battery overnight before each day of use*



Traceability



1. A primary reference lamp is maintained at the PTB in Germany.



3. Delta Light & Optics brings their own reference lamp where it is measured by the PTB equipment and given a calibration value.



2. The PTB calibrates their own photometric equipment to this lamp.



4. Delta Light & Optics maintains this reference lamp at their laboratory where it is used to calibrate their own photometric equipment.

5. Delta's calibrated photometric equipment is then used to determine the calibration values for the calibration standard used by the LTL 2000.





Maintenance Program



Through Flint Trading Inc.'s Annual Maintenance Program, factory trained and authorized personnel will thoroughly check, adjust and/or repair your instrument which fails to meet the high quality standards set by Delta Light & Optics during the original manufacture.

LTL 2000 MANUAL

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SECTION 1

OPERATING INFORMATION

LTL2000 Introduction

The LTL2000 Retrometer is a portable field instrument, intended for measuring the retro reflection properties of road markings in car headlight illumination, the value RI (coefficient of retro reflected luminance) is used. RI is a measure of the lightness of the road marking as seen by drivers of motorised vehicles in car headlight illumination. The road is illuminated at an angle of 1.24° and the reflected light is measured at an angle of 2.29° , which corresponds to an observation distance of 30 metres. Thus relevant for a motorist viewing situation under normal conditions.

RI is an important factor in the ON-SITE quality control of road markings.



Figure 1 LTL2000 Retrometer

The operation of the Retrometer is very simple and requires a minimum of instruction. An error message or warning is given in case of unreliable or erroneous measurement.

The LTL2000 measures the retro reflection and calculates RI according to international agreements. Results are presented in plain English on a 16*2 character LCD display. The built-in printer and non-volatile memory provides ON SITE registration of measurements with corresponding date and time.

Serial communication on RS232 port gives extended command, calibration, diagnostics and data dump facilities.

The LTL2000 is powered by a rechargeable lead acid battery, giving several hours of measurement capacity. A mains powered battery charger is supplied as standard.

LTL2000 Retrometer features:

- Portable self-contained instrument
- Measurement in full daylight
- Automatic stray light compensation and error diagnostics
- Dry and wet surfaces
- Plane, textured & profiled markings
- Measurement geometry and illumination corresponding to realistic viewing condition in night time traffic
- Direct digital read out
- Built-in printer
- Real time clock
- Automatic data storage in internal non-volatile memory
- RS232 serial communication for operation, data dump, extended control and diagnostics
- Automatic programmable power off function
- Easy calibration procedure
- Calibration unit
- Carrying case

Getting started:

Turn the LTL2000 on by pressing <ON>
Hold <ON> pressed until LCD shows:

Retrometer	Ready
LTL2000 rev. n	(Year date Time)

Calibrate instrument if necessary, see **Calibration**

Remove the base frame and place the instrument over the road marking.
Press <RL> button. Measurement will start instantly, duration app. 3 sec.

When finished the measured RI value, the date/time and status prompt is displayed.
The RI value, time and status is automatically transferred to the internal data log for later readout to the serial communication port.
Press the <PRINT> key to print the measurement result.

Calibration:

Zero calibration.

Mount the instrument in the base frame. Make sure that the light trap is absolutely clean and that the calibration unit is removed.

Press and hold <2'nd> and then press <ZERO>. Follow the shown instructions.

LCD shows the following text:

Zero Reading	Zero Reading	Zero Ok	Zero Ok
Enter to start	Please Wait	Zero: 0.11%	Ready

The instrument is now ready for the next step in the traceable- or control calibration procedure.

Traceable.

Open the hatch and place the reference calibration unit in the middle position as shown on the graphics on the bottom plate (see Appendix C - figure 24) and close the hatch.
Press <CALIB> and then <ENTER> to start. Follow the shown instruction.

LCD Shows the following text:

RI Normal Cal.	Mount Normal	Calibrating
Enter to Start	Enter when Ready	Please Wait
RI Normal = 146	RI Normal = 147	Calib Done
Enter=OK to edit	Enter when OK	Remove RI Normal

Edit the value until it corresponds with the Normal value and then press <ENTER>. The Calibration is now completed and the values stored.

Control Calibration.

Use in case of doubt during on site measurement.

Follow the traceable calibration procedure using the red control calibration unit. Use the RI value from the control calibration unit label.

Transfer of calibration value.

At regular intervals the traceable calibration value must be transferred from the reference calibration unit to the control calibration unit.

Mount the reference calibration unit and perform a **Traceable Calibration**, replace the reference calibration unit with the control calibration unit and make a normal RI measurement. Label the **Control Calibration Unit** with the value and the date.

Test, warning and errors

Warning and errors are indicated in the last positions in the display:

Status = *	Everything O.K.
Status = W	Warning Measurement O.K. but warning condition detected.
Status = L	Warning Measurement O.K. but high stray light detected.
Status = E	Error Measurement unreliable.

If the status code is different from * (zero value) then press <MENU> and select the *Status Display*. Use <↓><↑> to see the possible cause of the problem in plain text.

Use <2'nd><TEST> to execute a special test measurement. <TEST> will make a normal RI measurement and store the result and important parameters in the special Test Log. Use <PRINT> to print the result and the status information. If any special condition exists the status will be written in plain text.

Miscellaneous

Scrolling: Use <2'nd> and <↓><↑> for fast scrolling.

Power save: <MENU> until *Off time: nn sec.* <ENTER> and <↓><↑> to adjust. To disable the Auto Power Off function set the *Off time* to less than 60 sec. <ENTER> to accept.

Date/time: <MENU> until *Date and Time*. Then <ENTER> to enable edit, use <↓><↑> to edit Year then <ENTER> to switch to minutes and so on.

Reset log: <MENU> until *Free Log = xx.x%*. <ENTER> to reset.

Measurement ID: <↓> to enable editing of the Measurement ID. Use <↓><↑> to edit the indicated position and <ENTER> to switch to next position.

Deleting Data: <↑> to enable deletion of RI data from the top of the Data Log. The previous measurement result and its ID (if any) will be shown.

Communication

Use a simple terminal or PC with communication software to control the LTL2000. (Windows Hyper Terminal will do fine.)

Serial communication setup (RS232 interface):

9600 baud, No parity, 8 bit, 1 stop
Xon/Xoff handshake

Selected commands

?<CR>	(Help):	LTL2000 will return command set
LR<CR>	(Log dump):	Date, time, RI, status, mode.
LT<CR>	(Test log dump):	Date, time, RI, lamp on/off, idle, load, status, mode.
RL<CR>	(RI measurement):	RI, date, time, status code, system info.
RT<CR>	(Test measurement):	RI, date, time, status code, extended system info.
SD<CR>	(Status dump):	Instrument status.

Remember:

- Recharge battery when possible. Never leave battery discharged for longer periods of time.
- Keep protection window, light trap and calibration unit clean.
- LTL2000 is an optical precision instrument, handle with care.
- Store in clean and dry environment.

SECTION 2

GENERAL INFORMATION

RI Measurement

LTL2000 Retrometer measures the RI (coefficient of retro reflected luminance) parameter. The RI parameter represents the brightness of the road markings seen by drivers of motor vehicles by headlight illumination.

In the LTL2000 the illumination angle is 1.24° and the observation angle is 2.29° , simulating a drivers viewing distance of 30 metres at an eye height of 1.2 metres. The observation area is app. 45 mm. x 200 mm.

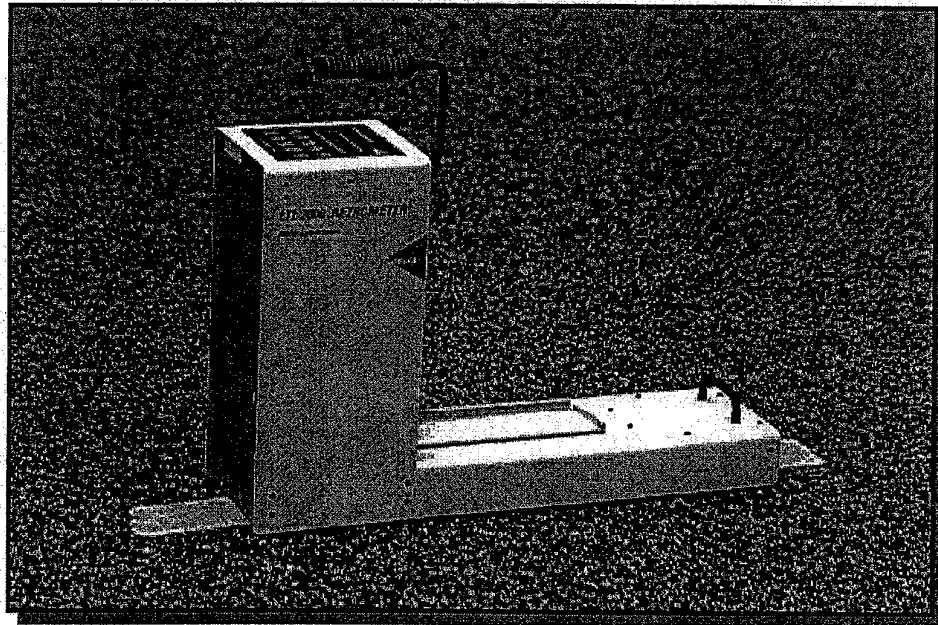


Figure 2 LTL2000 Side Look

Physically the Retrometer is dominated by the 'control' tower. The tower contains the illuminating and observation system and the control electronics. At the bottom of the tower an optical system, with mirrors, directs the beams towards the road surface through a dust-protection window. The measuring area is shielded by an aluminium housing with a rubber skirt and a light trap.

The LTL2000 is controlled by a microprocessor. The microprocessor executes the measurement automatically by the push of a button and presents the result on a display. The result is automatically transferred to an internal non-volatile memory. The result and corresponding time and date can be printed by the built-in printer. The LTL2000 is operated with a small keyboard located at the top of the Retrometer. Further, Retrometer control is possible over a serial

communication link (RS232). Stored data can easily be transferred to a host PC for further processing.

Factory calibration

The LTL2000 Retrometer is factory calibrated. This calibration is carried out by using a special calibration unit and a specially designed base frame. The calibration unit's RI value is measured in the laboratory using traceable methods and equipment.

The enclosed calibration unit and base frame can be used for the control and re-calibration of the Retrometer.

The LTL2000 is powered by a built-in lead acid battery, which under normal operation will keep the Retrometer operating a normal working day. The battery is recharged by use of an external charger.

Optical principle

The light is generated by a halogen lamp placed at the top of the tower, see Appendix C - figure 23. The light is focussed on a rectangular field stop and directed toward the illumination aperture at the front of the lens. Hereafter the beam is collimated by the lens and directed toward the road by a 50% beam splitter. The observation system is equivalent to the illuminating system. The reflected light enters the detection system mirror which deflects the light through the collimator lens and observation aperture to the detector unit in top of the tower.

Observation field and angle are defined by field stops and apertures. The retro reflected light is collected by the detection mirror and by the lens focussed on an optical fibre bundle. The light is by the optical fibre bundle guided to a photo multiplier. An optical filter is placed in front of the photo multiplier to obtain colour matching.

Notes on error sources

Stray light can enter the instrument between the rubber skirts and the road. Leakage will under normal measurement conditions not be significant. Nevertheless it may occur. Before each measurement the LTL2000 automatically evaluates the leakage. The result is compensated before read out. In case of a significant leakage level a warning or error message is given and special precautions may be necessary.

Instrument leak, drift and offset errors are compensated by means of data obtained during the calibration procedure. It is very important to keep the light trap, the dust-protection window and the ceramics on the calibration unit clean. Especially the light trap is critical.

The LTL2000 illumination angle is 1.24° relative to the road surface. Because of this small angle accurate placement on the road is important. Avoid pebbles and abnormal irregularities. The LTL2000 must be parallel and close to the road.

The LTL2000 Retrometer is a rugged instrument, but it is an optical instrument and must be handled as such.

The LTL2000 is factory calibrated. Nevertheless start important measurements with a calibration before removal of the base frame. Study the Retrometer status and error messages if any. See also Section 4 - Maintenance

Note

Keep light trap, dust-protection window and ceramics on calibration unit clean.
Keep battery fully charged. A well charged battery is more resistant to ageing and damage by freezing.

SECTION 3

KEYBOARD, DISPLAY AND FUNCTIONS

Keyboard Layout

RL TEST	CALIB . ZERO	ENTER CANCEL	MENU	OFF
2'nd	PRINT FEED	↓	↑	ON

Keyboard functions

Key Label	Key Function
-----------	--------------

ON	Turns the instrument On. Hold activated until the sign on message appears in the Display.
-----------	---

OFF	Turns the instrument Off. Terminates all activity and powers off.
------------	---

2'nd	Selects the keyboard function marked with black. First press and hold <2'nd> and then press one of the black functions. Activates fast scrolling mode with the up/down keys
-------------	---

RL	Does a Rl measurement and Shows the Rl result and measuring date and time in the display. The result, date, time, a short status and, if defined, a measurement ID with a measurement number will be stored in the Rl log for later dump to the communication port.
-----------	---

TEST	Begins an extended Rl measurement while recording various operating conditions. The results, date, time and a status will be stored in the Rl Test log for later dump to the communication port.
-------------	--

The following conditions are measured:

- Signal level
- Stray light level
- Battery conditions

A status number is generated from the following conditions.

- Error for signal overflow
- Warning for high stray light level
- Warning for critical low battery voltage
- Warning for signal overflow
- Warning for full Rl log (can be disabled)
- Warning for full Test log (can be disabled)
- Warning for pour measurement conditions

CALIB	Activates calibration measurement. The result is stored in the Test Log.
--------------	--

- ZERO** Activates instrument zeroing measurement. The result is stored in the Test Log
- ENTER** Activates selected function, accepts changed settings and confirms choices.
- CANCEL** Cancels selected function or menu and return to top control level displaying the latest RI result.
- PRINT** Outputs latest measurement result on printer.
Printout has to finish completely before any other function can be selected, printout can only be terminated with <OFF>.
- FEED** Feeds paper some lines.
- MENU** When in normal operation mode the <MENU> Key opens the menu system and displays the first item in the menu stack. When already in menu mode it selects the next menu item (<2'nd> <MENU> selects the previous menu item) cancelling any changes to the current menu function. It is possible to leave the menu mode entirely at any time and with no changes to the current menu function with the <CANCEL> key or by selecting one of the other key functions.
- ↑ Deletes the measurement from the top of the Data Log. The RI value from the previous RI measurement will be shown, if a Measurement ID was defined for that measurement it will be restored as well. If the menu system is selected it functions as a Scroll or Increment function. Values are incremented until they reach their predefined max. limit and then automatically change to their predefined min. limit. The key is auto repeating (press <2'nd> for fast increment).
- ↓ Edits the Measurement ID. If the menu system is selected it functions as a Scroll or Decrement function. Values are decremented until they reach their predefined min. limit and then automatically change to their predefined max. limit. The key is auto repeating. (Press <2'nd> for fast decrement)

Result Printout

RI Printout

```
RI: 145 mcd-m-2-lx-1
R#: 2 1997 Mar 20 16:18:50 Status: 0
```

Figure 3 LTL2000 RI Printout

The RI result printout showing the measured RI, the date and time for the measurement, the instrument status code and a R# number showing the number of measurements in the RI log. The RI result printout can only follow after a measurement performed with the <RI> key.

RI Printout with Measurement ID

```
RI: 146 mcd-m-2-lx-1
ID: Test # No: 6
R#: 5 1997 Mar 30 10:46:19 Status: 0
RI: 145 mcd-m-2-lx-1
ID: Test # No: 7
R#: 6 1997 Mar 30 10:46:28 Status: 0
RI: 145 mcd-m-2-lx-1
ID: Test # No: 8
R#: 7 1997 Mar 30 10:50:02 Status: 0
```

Figure 4 LTL2000 RI Printout with ID string and #

If the measurement ID has been set to anything other than 6 white space then the ID is printed along with a serial number showing the number of measurement done with that ID.

Test Printout

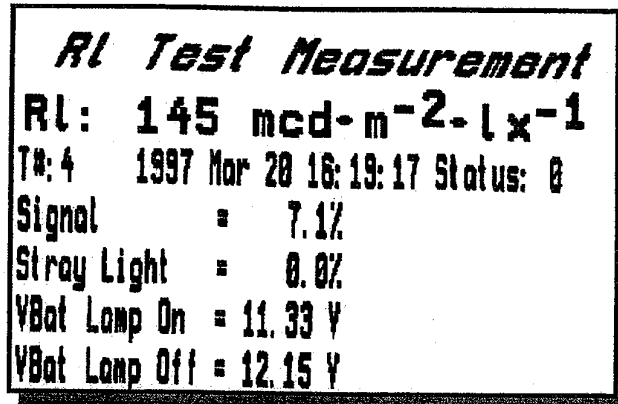


Figure 5 LTL2000 Test Printout

The Test Printout showing the measured RI, the date and time for the test, the related status code and a T# number showing the number of measurements in the Test log. The test printout can only follow after a measurement performed with the <2'nd> + <TEST> key.

Signal levels and battery conditions are measured during the measurement and printed.

If any special condition exists (status > 0) then the status code is decoded and the conditions are printed (see below), in the above example no special conditions exist. The measured signal and stray light levels are shown in % of their full scale values. The battery voltage before and during measurement is shown.

Status code interpretation:

	bit pattern	value	Description
Status Code:	00000001	1	Not defined
Status Code:	00000010	2	Stray Light Warning
Status Code:	00000100	4	RI Log full Warning
Status Code:	00001000	8	Test Log full Warning
Status Code:	00010000	16	Low Battery Warning
Status Code:	00100000	32	High Zero signal Warning
Status Code:	01000000	64	High Signal with Lamp on Error
Status Code:	10000000	128	High Signal with Lamp off Error

eg. Status code 18 is composed of Low Battery Warning (16) + Stray Light Warning (2)

Zero Printout

Zero Measurement
Zero Signal: 0.13% OK
T#: 2 1997 Mar 20 16:17:16 Status: 0

Figure 6 LTL2000 Zero Printout

The printout after a Zero measurement showing the measured Zero Signal in % of the nominal signal, if the zero signal is within a specified limit OK is printed, if the zero signal becomes high a warning is printed. A T# number showing the number of measurements in the Test log and the date and time for the measurement, The Zero printout can only follow after a measurement performed with the <2'nd> + <ZERO> key.

Calibration Printout

Calibration
RL Normal: 146 mcd-m⁻²-lx⁻¹
T#: 3 1997 Mar 20 16:18:13 Status: 0

Figure 7 LTL2000 Calibration Printout

The printout after a Calibration measurement showing the selected RL Normal value. A T# number showing the number of measurements in the Test log and the date and time for the calibration. The Calibration printout can only follow after a measurement performed with the <CALIB> key.

Functions and Menu system

RI Calibration (Activate with the <Calib.> key)	
LCD Display	Explanation.
RI Normal Cal. Enter To Start	Performs instrument calibration. <ENTER> opens RI Calibration sub menu.
Mount Normal Enter When Ready	The user is requested to place his RI-Normal in the LTL2000 instrument. Press <ENTER> when it is mounted correctly.
Calibrating Please wait	Measures RI on the mounted RI-Normal.
RI Normal 146 Enter=OK ↓↑=edit	The display shows the measured RI value. Use <ENTER> or <↓><↑> keys
RI Normal 146 Enter When OK	If necessary use the <↓><↑> keys to change the RI reading down or up, continue until the shown RI normal value is identical to the value printed on the calibration unit and press <ENTER>.
Calib Done Remove RI Normal	The display shows that a new RI Normal value has been calculated. The user is requested to remove the RI normal.
Zero measurement (Activate with the <2.nd.>+<ZERO> key)	
LCD Display	Explanation.
Zero Reading Enter to Start	Ready for measuring the instrument ZERO signal. Make sure that the light trap is mounted and empty, close the hatch and then press the <ENTER> key.
Zero Reading Please Wait	Measures the zero signal
Zero OK Zero: 0.11%	Zero measurement done no errors detected. The measured signal level is shown.
High Zero Warning Zero: 7.61%	Warning condition detected, the signal is to high. Check that the light trap is empty and clean. The following measurements will have the W status set.
Zero OK Ready	Instrument Zero OK, now ready for calibration.

Test Log (Select with the <Menu> key)	
LCD Display	Explanation.
Free T_LOG:95.6% Enter to Clear	The display shows the free space left in the Test log. Press <ENTER> to enable clearing. In order to avoid accidental erasing the data in the log, a second <ENTER> is required.
Enter to Confirm	Press <ENTER> again to set the Test Log to 100% free.
Clearing TestLog	Setting Test Log to 100% free.
RI Log (Select with the <Menu> key)	
LCD Display	Explanation.
Free LOG:89.3% Enter to Clear	The display shows the free space left in the RI Log. Press <ENTER> to enable clearing. In order to avoid accidental erasing the log, a second <ENTER> is required,
Enter to Confirm	Press <ENTER> again to set the RI Log to 100% free.
Clearing RI_Log	Setting RI Data Log to 100% free.
Print RI Log (Select with the <Menu> key)	
LCD Display	Explanation.
Print RI Log Enter to Select	Output all the data in the RI Log to the printer. Data in the Test Log can not be printed.
Log count =nn Enter to Print	The display shows the number of measurements in the Data Log. Press <ENTER> to start printing. The Print process continues until all the data has been printed,(newest first) The only way to stop is with the <OFF> key.

Enable/Disable Log Full Warning In LCD (Select with the <Menu> key)	
LCD Display	Explanation.
Log Warning Disable ↑ to Change	The Log Full Warning feature is disabled. Press <↑> to enable. Press <ENTER> to accept.
Log Warning Enable ↑ to Change	The Log Full Warning feature is enabled. Press <↑> to disable <ENTER> to accept.
Clear Top Log (Activate with the <↑> key after a RI measurement)	
LCD Display	Explanation.
Clear Top Log? Enter to Confirm	Removes the newest measurement from the RI Data Log. Confirm the removal with the <ENTER> key.
Clear Top Log? No Data in Log!	This message is shown when the RI Data Log is empty.
RI:...mcd/m ² /lx (ID-Text) or time	The previous RI result will be shown and if this measurement has an ID then this ID will also be restored together with its serial number. The time will not be updated!
Clear Top T-Log (Activate with the <↑> key after a Test, Calib or Zero measurement)	
LCD Display	Explanation.
Clear Top T-Log? Enter to Confirm	Removes the newest measurement from the Test Log. Confirms the removal with the <ENTER> key.
Clear Top T-Log? No Data in Log!	This message is shown when the Test Log is empty.
RI:....mcd/m ² /lx time	The previous result will be shown. The time will not be updated!

Measurement ID (Activate with the <↓> key)	
LCD Display	Explanation.
Seq ID:ABcd12 Enter to Edit	The Measurement ID is shown. Press the <ENTER> key in order to edit the 6 position ID string.
Seq ID:ABcd12 Edit ↑_____	An ↑ indicates the active edit position, use <↓><↑> to change the value above the pointer. Press <ENTER> to switch to the next position.
Seq ID:AB_#1 Edit _____↑	Press <ENTER> on the last position to activate the new Measurement ID, this also resets the serial number to 0 for the new ID.
Date and Time (Activate with the <Menu> key)	
LCD Display	Explanation.
Date and time Enter to Edit	The built-in real time clock can be set by selecting this menu function. Press <ENTER> to show the present setting. The format is year-month-day hour:minute
Edit Year 1997-03-18 13:30	Use <↓><↑> keys to change the setting. Press <ENTER> to switch to edit Month, edit Date, edit Hour and edit Minute. When the display shows the desired date and time press <ENTER> a last time to actually set the real time clock to the displayed setting.
Off Function (Select with the <Menu> key)	
LCD Display	Explanation.
Off Time:60 sec Enter to Edit or Off Timer disable Use ↓↑ to Edit	In order to prolong the operational time of the LTL2000 it has an automatic off function that shuts off the power when no action has been going on for more than a programmable time. The automatic turn off time can be from 60 to 600 seconds or it can be disabled entirely (time < 60 sec.).

Default setting (Select with the <Menu> key)	
LCD Display	Explanation.
Set ROM defaults Enter to Reset	If something goes wrong or appears to be wrong in the programming, it is possible to reestablish the default settings for various programmable values. This enables the user to start over from a default state. In order to avoid accidental reprogramming, a second <ENTER> is required.
Set ROM defaults Enter to Confirm	Press <ENTER> again to activate the action.
Setting Default Values from ROM	Default values are loaded from the permanent memory. The LOG data is NOT effected.
RI: 0 mcd/m ² /lx xx:xx:xx *	The instrument is now ready for new setup. Xx:xx:xx indicates no valid measurements done.
Status (Select with the <Menu> key)	
LCD Display	Explanation.
Status Display Use ↓↑ to View	The results and status made with the RI, Test, Calib. and the Zero functions can be displayed in the LCD one at a time by use of the <↓><↑> keys.
The following messages are possible.	
High Signal Warning Signal Overflow Signal = 12.4%	The measured signal strength in % of full scale. If the measured signal is over a predefined limit then a warning will be displayed for one second. The measured signal level is shown
High Stray Light Stray L = 0% Stray L = 4,51% No Stray L. Data	The measured stray light, representing the amount of light getting into the LTL2000 from outside. A high Stray Light signal can indicate problems with direct sunlight from a low sun on a very rough or uneven surface. Special precautions must be taken to hinder the light from shining directly on the measurement area. A warning is given in the display if the signal gets critical. Stray Light levels under a predefined limit are displayed as 0% No Stay Light data after a ZERO measurement.
Low VBat Warning VBat idle =10.6V	The battery voltage measured just before the lamp is lit. The reading can be used to check the charge condition of the built-in 12 V Lead Acid accumulator. A warning is given in the display if the voltage drops below its predefined minimum limit.

Low VBat Warning VBat load =11.2V	The battery voltage measured while the lamp is lit. The reading can be used to check the charge condition of the built-in 12 V Lead Acid accumulator. A warning is given in the display if the voltage under load drops to a critical low value. If the battery voltage gets very low, the LTL2000 will shut off during the measurement because the battery voltage drops below its predefined minimum level when the lamp is lit. This condition will be reported in the display on the next power Up. Measurements will not be possible until the battery is recharged or an external power source is applied.
RI=146 mcd/m ² /lx	The latest RI value measured.
RI Log Full or Free Log: 96.1%	A warning is given if the RI Log has run full. This means that it contains approx. 1000 RI readings, and that no new measurements can go into the log. The log will have to be emptied and cleared before this warning goes away. Also the measurement number in the printout will not change until the log is cleared. The amount of free log entries in %.
Test Log Full or Free T_Log: 87.5%	A warning is given if the RI Test Log has run full. This means that it contains approx. 100 test readings, and that no new Test measurements can go into the log. The log will have to be emptied and cleared before this warning goes away. Also the Test number in the printout will not change until the test log is cleared. The amount of free testlog entries in %.
LTL2000 rev. 2.0	The LTL2000 instrument ID and revision level.
(c)97-03-13	The firmware creation date.

LTL2000 Command set

The LTL2000 is equipped with a serial communication port primarily for log data acquisition, calibration and test, however all normal LTL2000 functions can be controlled from this interface.

The following commands have been defined

LTL2000 command set			
Command	Parameter	Response	Meaning
FV	none	Retrometer LTL2000 rev.2.0 DELTA L&O (c)97-03-13	The Firmware ID Revision number Copyright message Creation date
LR	none	LTL Log Dump: 1997 Mar 27 10:01:53 6 entries 99.56% free Date Time RI Status ID # Y-M-D H:M:S (mcd/m ² /lx) 1997-03-27 10:00:59 146 0 1997-03-27 10:01:11 146 0 1997-03-27 10:01:22 146 0 12345 1 1997-03-27 10:01:28 146 0 12345 2 1997-03-27 10:01:45 146 0 Test # 1 1997-03-27 10:01:50 146 0 Test # 2 *	Log dump date and time Log statistics Log header Data units RI data without Measurement ID RI data with Measurement ID Measurement ID changed
LS	none	RI DataLog: 6 data points. 99.56% free RI TestLog: 3 data points. 98.80% free	End of log RI log statistics Test log statistics
LE	none	1997-03-27 10:00:59, 146, 0, , 1997-03-27 10:01:11, 146, 0, , 1997-03-27 10:01:22, 146, 0, 12345, 1 1997-03-27 10:01:28, 146, 0, 12345, 2 1997-03-27 10:01:45, 146, 0, Test A, 1 1997-03-27 10:01:50, 146, 0, Test A, 2	Data in RI Log is output comma separated for input to standard spreadsheet

LTL2000 command set				
Command	Parameter	Response	Meaning	
LT	none	LTL2000 Test Log Dump: 1997 Mar 27 10:01:03 3 entries 98.80% free Date Time Y:M:D H:M:S 1997-03-27 10:00:34 1997-03-27 10:00:45 1997-03-27 10:01:03 * Rl Log empty	Test log dump date and time Log statistics Log header Data units Rl zero Rl calibration Rl test measurement	
LC	none	Rl Log empty	Rl log clear message	
LX	none	Rl Test log empty	Rl test log clear message	
RC	none Y	Calibrate Instrument? [Y/N] Calibrating Instrument! **** Calibration **** Lamp On: 163 Lamp Off: 10 Stray Light: 0 On-(Off+SyLeak): 151 Now use RN n command to set new normal value	Confirm calibration with <Y> Perform calibration measurement Signal with lamp on Signal with lamp off Stray light signal Compensated signal Prompt the user to execute the RN command to enter the correct Rn Value	
LWT LWF	none	Log Full Warning Display On Log Full Warning Display Off	Enable the Log Full warning in LCD Disable the Log Full warning in LCD	
RL	none	*** Rl Measurement *** 1997 Mar 27 10:00:59 Rl: 146 (mcd/m ²)/lx Status Code: 0 00000000	Performs a normal Rl measurement. Displays measurement date and time, the Rl result and the Status code	
RZ	none	* **** Zero Reading *** Lamp On: 12 Lamp Off: 10 New Rl Sy Leak: 2	Perform zero measurement Signal with lamp on Signal with lamp off New SyLeak signal	

LTL2000 command set			
Command	Parameter	Response	Meaning
RN	none	RI_Factor = 2.312 RI_Normal = 138	Calculated RI factor RI calibration value
	150 (RI Normal)	RI_Factor = 2.151 RI_Normal = 120	Calculated RI factor based on the new RI normal value entered 150 ncd/m ² /lx
RT	none	*** Test Measurement *** 1997-Mar-27 10:01:03 RI = 146 (ncd/m ²)/lx Signal: 7.3% Stray Light: 0.0% VBat Lamp Off: 12.18 V VBat Lamp On: 11.28 V Status Code: 0 00000000	Test header date and time Date and Time Measured RI result Measured signal Measured stray light signal Battery voltage with min. load Battery voltage with max. load Actual Status code
DT	none	*** RI Test Measurement *** 1997-Mar-27 10:02:30 RI = 144 (ncd/m ²)/lx Signal: 7.3% Stray Light: 0.0% VBat Lamp Off: 12.21 V VBat Lamp On: 11.30 V Status code: 0 00000000	Latest test result Date and Time Measured RI result Measured signal Measured stray light signal Battery voltage with min. load Battery voltage with max. load Actual Status code

LTL2000 command set			
Command	Parameter	Response	Meaning
DR	none	*** RI Measurement *** 1994-Mar-27 10:03:56 RI: 145 (mcd/m²)/lx Status Code: 0 00000000	Query Latest RI Measurement Date and time Result Status
TO	none	Sensor Off	Turn sensor off (power off)
OT	none 59 180	Automatic off timer = 120 sec. Automatic off function disable Automatic off timer = 180 sec.	Automatic turn off time when not in use. Range 60 to 600 sec. Disable for time < 60 sec
VB	none	VBat = 12.21 V	Measure actual voltage on lead-acid battery
VA	none new setpoint	Low VBat alarm: 11.0 V Low VBat alarm: new value V	Setpoint for low bat warning New set point for low bat warning
VF	none wanted [V]	Volt Factor = 0.0153 Volt Factor = 0.0146	Voltage calibration factor New wanted reading (in Volt!)
VS	none	VBat Lamp off: 12.21V VBat Lamp on : 11.30V	Measured VBat with min. load Measured VBat with max. load
MC	none new count	Averring Measurement count 1000 New value for averring	Number of single measurements used to build an average signal for calculation of RI New value The instrument is now un calibrated !
SD	none	Actual Status Code: 0 Bit Pattern: 00000000 Status breakdown: Actual Status Code: 16 00010000 Warning: Low VBat	Status code and bit pattern if status not zero then the status code is decoded This example shows a status value of 16. It decodes to Warning for low battery voltage
DA	none 1997 3 27	1997 Mar 21 09:45:47 1997 Mar 27 16:39:45	Real time clock Date and time New Date (time unchanged)
TI	none 10:0:0	1997 Mar 27 16:45:51 1997 Mar 27 10:00:00	Real time clock Date and Time New Time (Date unchanged)

LTL2000 command set			
Command	Parameter	Response	Meaning
MC	none	Averring Measurement count 1000	Number of single measurements used to build an average signal for calculation of RI New value The instrument is now un calibrated !
	new count	New value for averring	
SD	none	Actual Status Code: 0 Bit Pattern: 00000000 Status breakdown:	Status code and bit pattern if status not zero then the status code is decoded
		Actual Status Code: 16 00010000 Warning: Low VBat	This example shows a status value of 16. It decodes to Warning for low battery voltage
DA	none	1997 Mar 21 09:45:47	Real time clock Date and time
	1997 3 27	1997 Mar 27 16:39:45	New Date (time unchanged)
TI	none	1997 Mar 27 16:45:51	Real time clock Date and Time
	10.0.0	1997 Mar 27 10:00:00	New Time (Date unchanged)
II	none	Initialise Instrument settings [Y/N]	Set Default values from ROM
	Y	Initialising Instrument. Zero and Calibrate	Execute initialisation, Instrument not calibrated!
	N	II Command Terminated	Cancel initialisation command without any change

LTL2000 command set			
Command	Parameter	Response	Meaning
<?>	none	Date [yyyy mm dd] display/set Date DR Dump RI Signal DS Dump Signal DT Dump RI Test DPP Dump Extra Status to Printer DPS Dump Extra Status to RS232 FV Firmware Version II Initialise Instrument settings [Y/N] LC RI Log Clear LR RI Log Dump LERI Log Dump <lab> separated LS Log Status LT Test Log Dump LX Test Log Reset LWn Log Warning MC Average Measuring Count OT n Auto Off Timer	Query/Set Real Time Watch Date year/month/date Query last RI result Query Signal Status Query last Test result Dump extended status to printer (see appendix B) Dump extended status to RS232 port (see appendix B) Query Firmware ID Enable/Execute Instrument Initialisation Clear RI Data log Send RI log to RS232 Port Send Special <TAB> separated RI log to RS232 Query log status Send Test log to RS232 Port Clear Test log Enable/Disable the Display of Log full warning [T/F] Query/Set the Averring Count for noise reduction Query/Set the Automatic Turn Off Timer

LTL2000 command set			
Command	Parameter	Response	Meaning
<?> (contin.)	None	PV PMT Voltage PF PMT Volt factor RC Calibration Measurement RL RI Measurement RN n Normal Measurement RT Test Measurement RZ Zero Measurement SD Status Dump SN Measurement ID TI Time [hh:mm:ss] Display/Set time TO Turn Sensor Off VA Volt Alarm for Low Bat VB VBat VF Volt factor VS Return Volt-Idle, Volt-Load	Query PMT voltage Calibrate V-PMT Execute Calibration measurement Execute RL measurement Query/Set RI Normal value Execute Test measurement Execute Instrument Zero measurement Query instrument status Query/Set Measurement ID Query/Set Real Time Turn LTL2000 off Query/Set Alarm for low Battery voltage Query Battery Voltage Calibrate Voltage reading Query V-Bat for Idle and Load conditions

SECTION 4

MAINTENANCE

General care

The Retrometer is constructed for outdoor use in ordinary good weather conditions. It will stand moist weather with wet roads, but caution must be taken against rain or splashes and dirt from traffic. The LTL2000 Retrometer is an optical instrument and shall be handled as such. Avoid shock and vibration if possible.

Note

Keep dust protection window and light trap clean.

Protection window

The protection window is located in the optical unit, see Appendix C - figure 23. The protection window is coated with a high efficiency anti reflection coating. Care must be taken not to damage this coating by cleaning. A fine brush can be used for removing loose particles/dust. If this is not sufficient the window should be cleaned using a soft paper tissue or cloth and some window cleaning liquid.

Battery

The LTL2000 Retrometer is powered by a sealed 12V/3.5Ah lead acid battery, which under normal use requires no maintenance. However it is recommended to keep the battery fully charged. A fully charged battery is more capable of withstanding low temperature and ageing.

Battery charger is provided as a standard accessory for charging the battery from mains. The output cable of the charger is equipped with a socket matching the connector in the instrument. Connect charger to mains and instrument. The red indicator will be switched on as long as the charging is in progress. Thereafter it switches periodically on and off. Normally the charging will take about 8-12 hours. Typically the battery achieves 90% of the capacity in 5 hours. No harm will result from leaving the charger connected for time in excess of the above indicated duration of the charging process. However, the battery must be disconnected from the charger when disconnecting the mains.

The battery is located in a compartment at the front of the tower. To replace the battery remove the screws holding the right side cover plate, seen from behind. Remove the screws from the right hand side of the red front- and back cover plate. Remove the side cover plate. Remove the 2 nuts holding the clamp plate. Lift out the battery of its container. The battery can now be removed and renewed. Refit in reverse order.

Fuses

Fuses, two pieces, are placed at the rear of the instrument. The charging fuse protects the battery against short circuit and other errors in the charging connector, charger or charging system.

The battery fuse protects battery and electronics against short circuit and other errors in the electronic system.

Always renew a blown fuse with one of equal rating. To change a fuse carefully unscrew the plastic cap fuse holder by using eg a coin. Pull out the fuse from the cap and insert the new one and reassemble.

Lamp

The halogen lamp requires no maintenance. At life end it must be renewed.

It is recommended that renewing is done by trained personal.

Calibration unit

The road marking is simulated by a piece of white ceramics mounted on a aluminium block with a small grip. Ceramics has very stable optical properties and cleaning is easy because of the smooth surface.

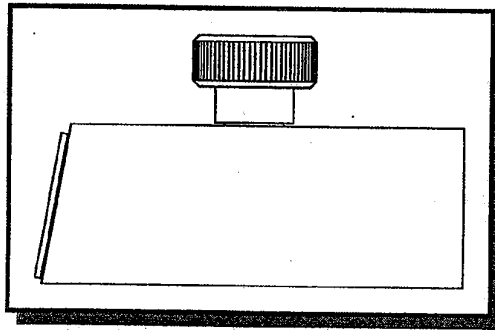


Figure 8 Ceramics RI Calibration Unit

To make sure that calibration of the Retrometer is correct it is important that the ceramics on the calibration unit is clean and undamaged. All ways keep the calibration unit well protected.

If the ceramics is stained, scratched or broken the calibration unit has to be renewed.

In case of dust on the ceramics surface, clean gently with a damp soft cloth if necessary use a mild household detergent.

To ensure reliable measurements, it is recommended that the calibration unit is periodically recalibrated to a traceable standard. DELTA Light & Optics offers calibration traceable to PTB (Physikalisches Technische Bundesanstalt). For information contact your distributor or DELTA Light & Optics.

Light trap

Zero signal is simulated by a light trap made of two glossy and black plastic sheets mounted in an acute angle. If clean this will provide very efficient light absorbing device.

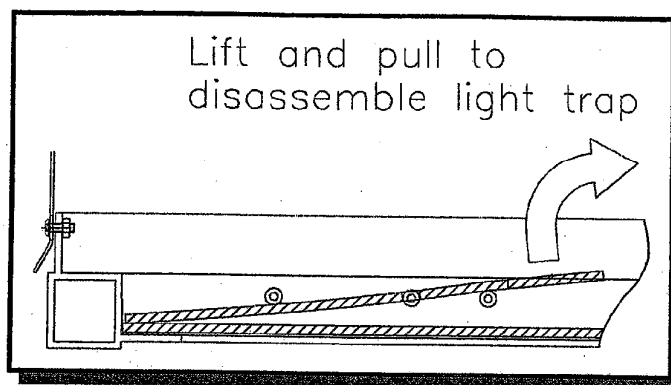


Figure 9 Zero Calibration Light Trap

The light trap is the tilted black plastic sheet and the area below. The light trap is a part of the base frame. The base frame is also used for transport protection.

It is necessary to disassemble the light trap to clean it efficiently. This is easily done as shown in Figure 9. Cleaning can be done by using a fine brush, clean pressurised air or a soft paper tissue/cloth and some window cleaning liquid.

Calibration

The LTL2000 is factory calibrated and very stable; but a calibration should always be carried out before starting a new series of measurements.

The instrument is supplied with two calibration units. A reference calibration unit (aluminium base) and a work calibration unit (red plastic base). The reference calibration unit is factory calibrated and traceable to PTB. The work calibration unit must be calibrated against the reference calibration unit by the user at suitable intervals. The reference calibration unit is stored in a protective box. The work calibration unit is placed in a compartment below the printer. This facilitates easy access during field operation.

When calibrating, first mount the LTL2000 in its base frame and then perform a <ZERO> reading. Then open the hatch in the instrument and place the calibration unit on the black plastic sheets right over the middle marking and with the ceramics surface pointing in the shown direction towards the tower, close the hatch and perform a <CALIB.> reading. Now edit the suggested RL value with the edit keys so that it matches the value printed on the calibration unit and RI and then press <ENTER>.

The instrument automatically compensates for zero signal, leakage and other known errors, and

calculates the calibration factor. This process is fully **automatic** and if the calibration routine is followed precisely the Retrometer will now display 'True' Rl.



Figure 10 Mounting Instrument on the Base Frame for Zero and Calibration measurements.

Always store the reference calibration unit in a dry and clean environment. At regular intervals the traceable calibration value must be transferred from the reference calibration unit to the control calibration unit.

See also section 1: *Calibration* and section 3: *Functions and Menu system* and *Command set*.

Printer

The printer is a high speed high quality Mini Thermal Printer. It uses 57.5 mm thermal paper. It has only a few moving parts and does not require any special or periodic maintenance.

Replacing the paper is easily done by first pushing the spring loaded transparent cover downwards to disengage it from the upper black part, let it swing down and insert a new paper roll. A handwheel makes it easy to insert the paper. Close the cover in reverse order.

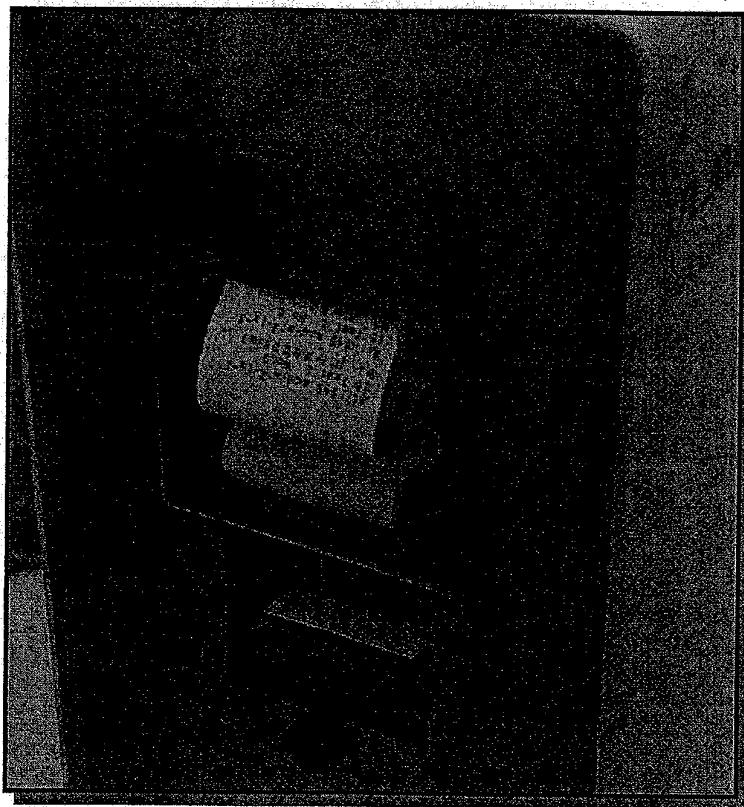


Figure 11 Thermal Printer Location

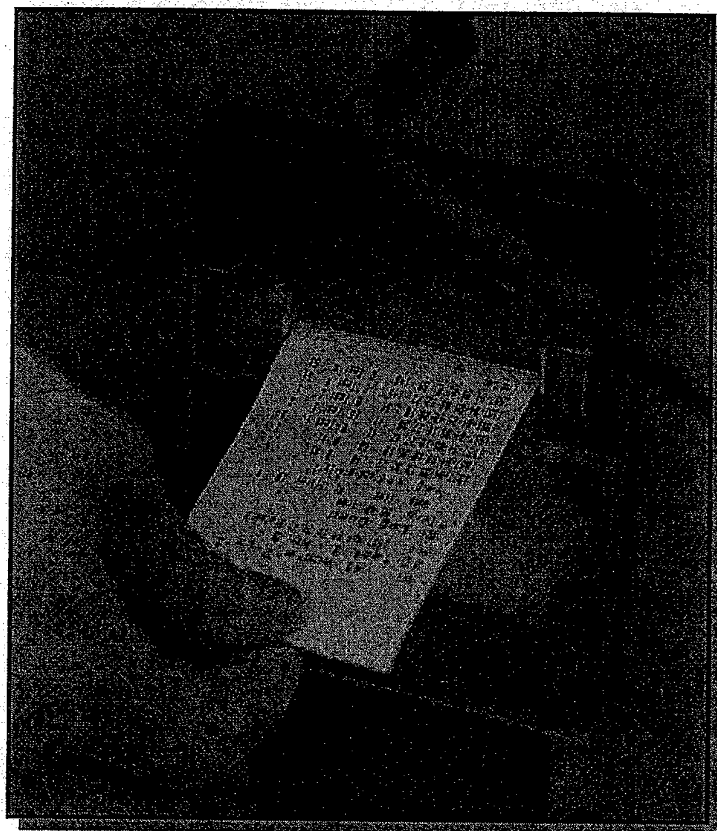


Figure 12 Paper Ripoff

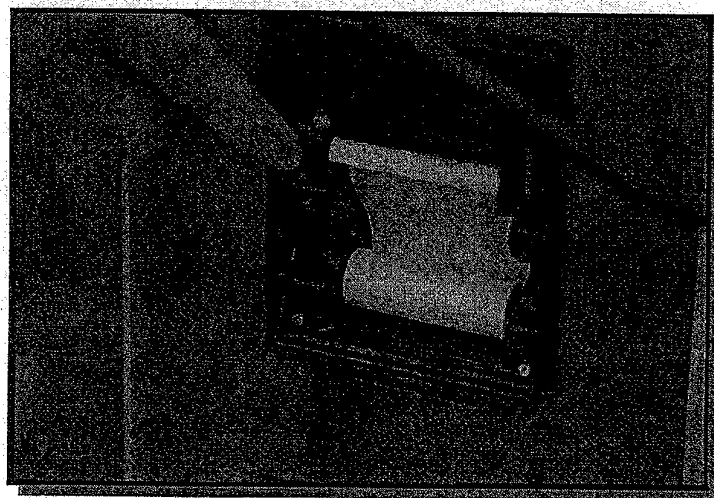


Figure 13 Replacing Paper

APPENDIX A

COMMUNICATION FACILITIES

RS-232C specification

The LTL2000 is equipped with a communication facility that enables the use of a simple data terminal or an ordinary PC type computer for control of LTL2000 functions and for log data acquisition.

The computer or terminal connects to the LTL2000 using a communication cable fitted with a 9 pin male D-Sub connector at one end and a 9 or 25 pin connector at the other end.

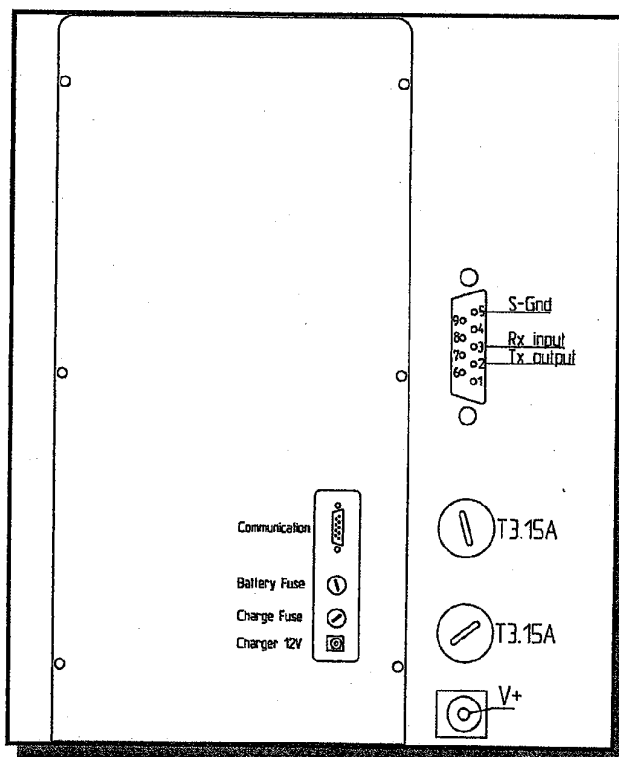


Figure 14 Connections

The electrical connections meet the EIA/TIA-232E and CCITT V.28 specifications. e.g. it can be connected to any standard RS232 serial communications port with the below wiring.

Connections in the 9 pin D-Sub connector.

pin #	Function	Signal Direction
3	Receive Data	Data to LTL2000
2	Transmit Data	Data from LTL2000
5	Signal Ground	Signal Ground

Connection example #1. PC with 25-pin D-Sub communication port.

Cable connections:

PC Port DTE	pin name	LTL DTE	
1	FG	X	
2	TxD	---	3
3	RxD	---	2
4	RTS	X	
5	CTS	X	
6	DSR	X	
7	SG	---	5
8	DCD	X	
20	DTR	X	

25-pin female
D-SUB

9-pin male
D-SUB

Connection example #2. PC with 9 pin D-Sub communication port.

Cable connections:

PC Port DTE	pin name	LTL DTE	
1	CD	X	
2	RxD	---	2
3	TxD	---	3
4	DTR	X	
5	SG	---	5
6	DSR	X	
7	RTS	X	
8	CTS	X	
9	RI	X	

9-pin female D-SUB 9-pin male D-SUB

As it can be seen, the interconnections have been held to an absolute minimum, and in some rare situations there will have to be established additional connections on the PC side. Please refer to your PC manual for further information.

Data protocol

The communication between the LTL2000 and the computer equipment takes place using the following settings:

Baud Rate 9600 bit/sec.
 Number of data bit 8
 Parity none
 Stop bit 1
 Hand Shake XOn/XOff

Command format

All LTL2000 commands are built using the following template.

Command (one ore more letters)
Delimiter (one ore more spaces, optional)
Parameter (Integer or Real number, optional)
Command End (Carriage Return, mandatory)

Example #1:

The user wants to see how the Automatic Off timer is set and then change the value to 120 seconds.

The command and the response sequence look like this.

```
ot
Automatic Off Timer = 300 sec.
ot 120
Automatic Off Timer = 120 sec.
```

Figure 15 Off Timer example

If for some reason the communication fails or the command is undefined the LTL2000 responds with a question mark. <?>

If the parameter lies outside the defined range for that parameter, the LTL2000 returns the present setting without any change.

Example #2:

The user wants to read the data in the Data Log

The command and the response sequence can look like this.

```
lr
LTL Log Dump: 1997 Mar 21 08:38:14
10 Entries: 99.26% free
  Date      Time      RL      Status  ID  #
  Y-M-D      H:M:S (mcd/ny)/lx
1997-03-20 16:18:50  145      0
1997-03-20 16:34:37  149      0
1997-03-20 16:35:03  149      0      #1-z  1
1997-03-20 16:35:06  149      0      #1-z  2
1997-03-20 16:35:11  149      0      #1-z  3
1997-03-20 16:35:22  149      0      #2-z  1
1997-03-20 16:35:25  149      0      #2-z  2
1997-03-20 16:35:32  149      0
1997-03-21 08:25:34  143      0
1997-03-21 08:26:04  143      0
+
```

Figure 16 Log Data example

APPENDIX B

Special Status Printouts.

The LTL2000 can print a special status at power up showing all internal settings and values generated by the different functions.

The status printout is activated by holding the keys <2'nd> and <PRINT> activated during power up. Once the print process has started release all keys and wait for the completion. The print process can only be turned off with the <OFF> key.

The following sequence of measurements and printouts was done to show the kind of information the user can get under different conditions. First the instrument was reset with the II function and the data and the test log was cleared. Then a Zero measurement was done followed by a calibration, and a normal RI measurement was taken, and finally a test measurement was executed. The instrument status was printed after each step using the described procedure.

The purpose of this Special Status Printout is to give the user an easy way to communicate the instrument status to a technician in case of problems.

A similar Status can be generated with the DPP command.

Initial Status

After executing a ZERO function the status will look like this.

It shows that no Zero measurement has been executed and also no Calibration.

The values for the highvoltage (VPMT) and battery voltage are set to their default values.

The Data log status is shown.

The special status shows the setting for the MODE Switch, the measurement counts for noise reduction, the automatic off timer, the actual voltage on the battery, the date and time and finally the firmware revision # and creation data.

Finally is shown the e-mail address and the WWW address to DELTA.

Note that the Real Time Clock and the Data Logs normally will not be affected by a Set ROM Defaults or a II command.

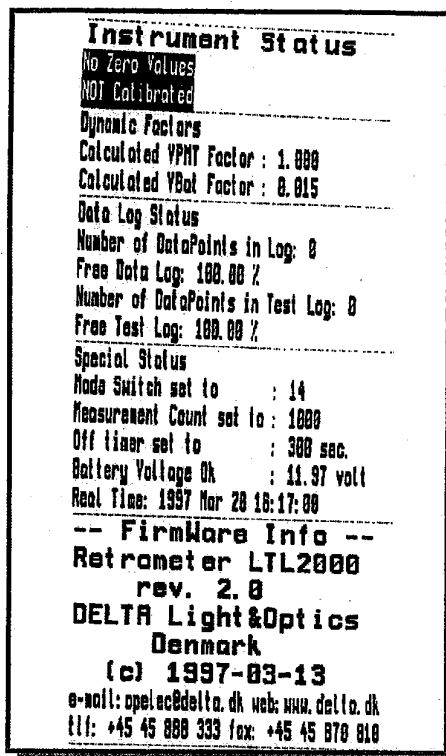


Figure 17 Initial Status

Status after first Zero

After executing a ZERO function the status will look like this.

It shows that the Zero measurement has been executed and when this was done.
No calibration has been done yet.

The values recorded during the zero measurement, the system leak, the dark signal and the offset signal are listed.

The voltage conditions during the zero measurement are shown:

Battery voltage measured when the lamp is on, the voltage with the lamp off and finally the PMT voltage:

It can be seen that the data from the zero measurement went into the Test Log.

Instrument Status	
Zero Measurement Done: 1997 Mar 28 16:17:18	
NOT Calibrated	
Measurement Results	
Values from last Zero measurement	
System Leak	: 3 18.13%
Dark Signal	: 12
Offset Signal	: 9
Dynamic Factors	
Calculated YPM Factor	: 1.889
Calculated YBat Factor	: 0.815
Volt Measurements	
YBat Lamp On	: 11.36 volt
YBat Lamp Off	: 12.28 volt
YPM measured to	: 489 volt
Data Log Status	
Number of DataPoints in Log	: 8
Free Data Log	: 100.00 %
Number of DataPoints in Test Log	: 1
Free Test Log	: 99.99 %
Special Status	
Mode Switch set to	: 14
Measurement Count set to	: 1000
Off timer set to	: 300 sec.
Battery Voltage Ok	: 11.97 volt
Real Time	: 1997 Mar 28 16:17:55
-- Firmware Info --	
Retrometer LTL2000	
rev. 2.0	
DELTA Light & Optics	
Denmark	
(c) 1997-03-13	
e-mail: opelco@delta.dk web: www.delta.dk	
tlf: +45 45 888 333 fax: +45 45 878 810	

Figure 18 Status after Zero Measurement

Status after Calibration

After executing a Calibration function the status will look like this.

Data from the Calibration measurement is added to the list.

Also the calculated RI Factor is added to the list.

It can be seen that the data from the calibration measurement went into the Test Log.

Instrument Status	
Zero Measurement Date:	1997 Mar 28 16:17:16
Calibration Normal:	146 $\text{mcd} \cdot \text{m}^{-2} \cdot \text{lx}^{-1}$
Instrument Calibration:	1997 Mar 28 16:16:13
Measurement Results	
Values from last Zero measurement	
Signal Lock :	3 (0.132)
Dark Signal :	12
Offset Signal :	9
Values from last Calibration	
Signal :	146
Lock :	1
Long On / Off :	157 / 10
Dynamic Factors	
Calculated VPM Factor :	1.688
Calculated VRI Factor :	6.815
Calculated RI Factor :	2.818
Calibration Ref. :	146 $\text{mcd} \cdot \text{m}^{-2} \cdot \text{lx}^{-1}$
Volt Measurements	
Vbat Long On :	11.41 volt
Vbat Long Off :	12.28 volt
VPM measured to :	477 volt
Data Log Status	
Number of DataPoints in Log :	8
From Data Log :	100.00 %
Number of DataPoints in Test Log :	2
From Test Log :	98.20 %
Special Status	
Mode Switch set to :	14
Measurement Count set to :	1000
Off time set to :	300 sec.
Battery Voltage Oh :	11.90 volt
Next Time :	1997 Mar 28 16:16:37
-- Firmware Info --	
Retrometer LTL2000	
rev. 2.8	
DELTA Light & Optics	
Denmark	
(c) 1997-03-13	
e-mail: opt@delta.dk web: www.delta.dk	
tlf: +45 45 888 930 fax: +45 45 818 810	

Figure 19 Status after Calibration

Status after RI measurement

After executing a Normal RI Measurement the status will look like this.

Data from the RI measurement is added to the list.

It can be seen that the data from the RI measurement went into the Data Log.

Instrument Status	
Zero Measurement Done:	1997 Mar 28 18:17:16
Calibration Normal:	$146 \text{ mcd} \cdot \text{m}^{-2} \cdot \text{lx}^{-1}$
Instrument Calibrated:	1997 Mar 28 18:18:13
Measurement Results	
Values from last Zero measurement	
System Leak :	3 (3.13%)
Dark Signal :	12
Offset Signal :	9
Values from last Calibration	
Signal :	144
Leak :	0
Lamp On / Off :	157 / 18
Values from last RI Measurement	
Done at:	1997 Mar 28 18:18:50
Result :	145
Signal :	144
Leak Signal :	0
Dynamic Factors	
Calculated VPNT Factor :	1.000
Calculated VBat Factor :	0.915
Calculated RI Factor :	2.918
Calibration Ref. :	$146 \text{ mcd} \cdot \text{m}^{-2} \cdot \text{lx}^{-1}$
Volt Measurements	
VBat Lamp On :	11.36 volt
VBat Lamp Off :	12.18 volt
VPNT measured to :	478 volt
Data Log Status	
Number of DataPoints in Log:	1
Free Data Log:	99.99 %
Number of DataPoints in Test Log:	2
Free Test Log:	99.28 %
Special Status	
Mode Switch set to :	14
Measurement Count set to :	1000
Off timer set to :	300 sec.
Battery Voltage Ok :	11.97 volt
Real Time:	1997 Mar 28 18:19:11
-- Firmware Info --	
Retrometer LTL2000	
rev. 2.0	
DELTA Light & Optics	
Denmark	
(c) 1997-03-13	
e-mail: opetek@delta.dk web: www.delta.dk	
tel: +45 45 000 333 fax: +45 45 870 810	

Figure 20 Status after RI Measurement

Status after a Test measurement

After executing a Test Measurement the status will look like this.

The values from the Test measurement are added to the list.

It can be seen that the data from the Test measurement went into the Test Log.

Instrument Status	
Zero Measurement	Date: 1997 Mar 28 18:17:18
Calibration Normal:	146 $\text{mV} \cdot \text{m}^{-2} \cdot \text{lx}^{-1}$
Instrument Calibrated:	1997 Mar 28 18:18:13
Measurement Results	
Values from last Zero measurement	
System Leak	: 9 18.1323
Dark Signal	: 12
Offset Signal	: 9
Values from last Calibration	
Signal	: 144
Leak	: 9
Lamp On / Off	: 157 / 18
Values from last Test Measurement	
Done at	: 1997 Mar 28 18:19:17
Result	: 146
Signal	: 146
Leak Signal	: 9
Values from last RI Measurement	
Done at:	1997 Mar 28 18:18:58
Result	: 145
Signal	: 144
Leak Signal	: 9
Dynamic Factors	
Calculated YPM Factor	: 1.888
Calculated YBat Factor	: 0.815
Calculated RI Factor	: 2.618
Calibration Ref.	: 146 $\text{mV} \cdot \text{m}^{-2} \cdot \text{lx}^{-1}$
Volt Measurements	
YBat Lamp On	: 11.33 volt
YBat Lamp Off	: 12.16 volt
YPM measured to	: 474 volt
Data Log Status	
Number of DataPoints in Log:	1
Free Data Log:	99.99 %
Number of DataPoints in Test Log:	3
Free Test Log:	99.99 %
Special Status	
Mode Switch set to	: 14
Measurement Count set to	: 1888
Off timer set to	: 388 sec.
Battery Voltage Ch.	: 11.97 volt
Real Time:	1997 Mar 28 18:19:40
-- Firmware Info --	
Retrometer LTL2000	
rev. 2.0	
DELTA Light & Optics	
Denmark	
(c) 1997-03-13	
e-mail: spelec@delta.dk web: www.delta.dk	
tel: +45 45 808 333 fax: +45 45 878 810	

Figure 21 Status after Test Measurement

APPENDIX C

SPECIFICATION

Table 1-1 General Characteristics

Illumination angle	1.24°
Observation angle	2.29°
Equivalent observer distance	30 m
Observation angular spread	±0.17°
Type 30m CEN	
Illumination angular spread horizontal	0.33°
Illumination angular spread vertical	0.17°
Type 30m ASTM	
Illumination angular spread horizontal	0.10°
Illumination angular spread vertical	0.10°
Field of measurement:	
Width	45 mm (1.8 in)
Length (typ.)	200 mm (7.9 in)
Min. reading (mcd/m ² /lx)	0
Max. reading (mcd/m ² /lx)	Typ. 2000

Table 1-2 Electrical Characteristics

EMC	EN 50081-1 EN 50082-1
Power supply:	
Battery	Build in 12 volt 3.5Ah sealed lead acid
External charger	230 VAC charging time app. 10 hours 90% capacity after app. 5 hours
Charger fuse (5*20 mm)	T3.15A
Power supply fuse (5*20 mm)	T3.15A
Data memory	>1000 measurements
Data retention (from purchase)	Typ. 5 years
Serial communication mode	9600,N,8,1
Data flow control	Xon/Xoff
Interface	Modified RS 232

Table 1-3 Environmental Characteristics

Temperature:

Operating 0°C to +45°C (32° F to +114° F)

Storage*) -15°C to +55°C (5° F to +131° F)

Humidity Non condensing

*)Battery must be fully charged

Table 1-4 Mechanical Characteristics

Max. length 720 mm (28.3 in)

Max. width 200 mm (7.9 in)

Max. height 570 mm (22.4 in)

Weight app. 11 kg (24 lbs)

Shipping Weight app. 22 kg (49 lbs.)

Construction:

Housing Aluminum

Keyboard Plastic laminated

Circuit boards Epoxy glass

Printer:

Thermal Paper with/dia. 57.5mm/35mm (2.26 in/1.38in)

Dimensional drawings

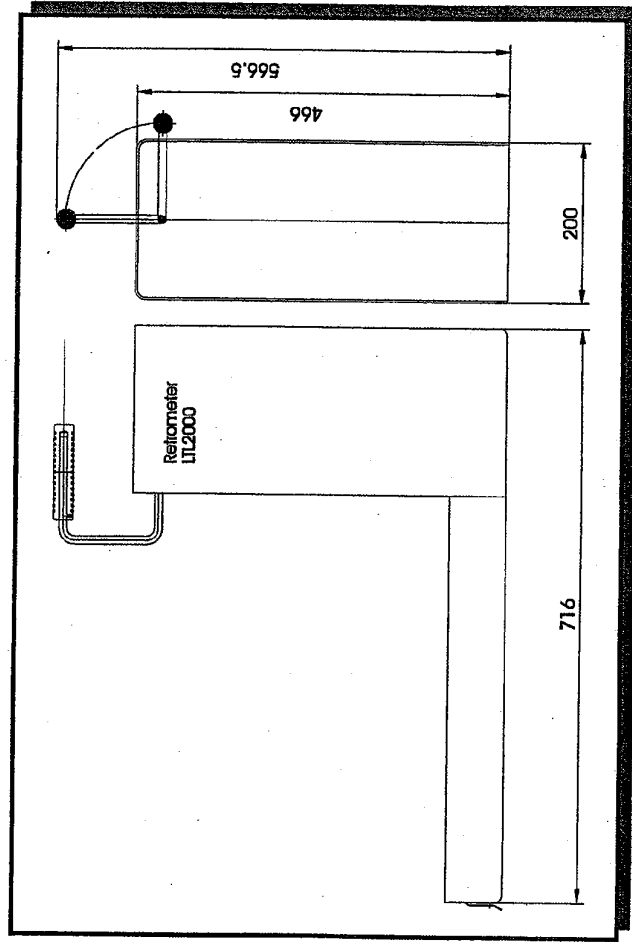


Figure 22 LTL2000 dimensions (mm)

Instrument Layout.

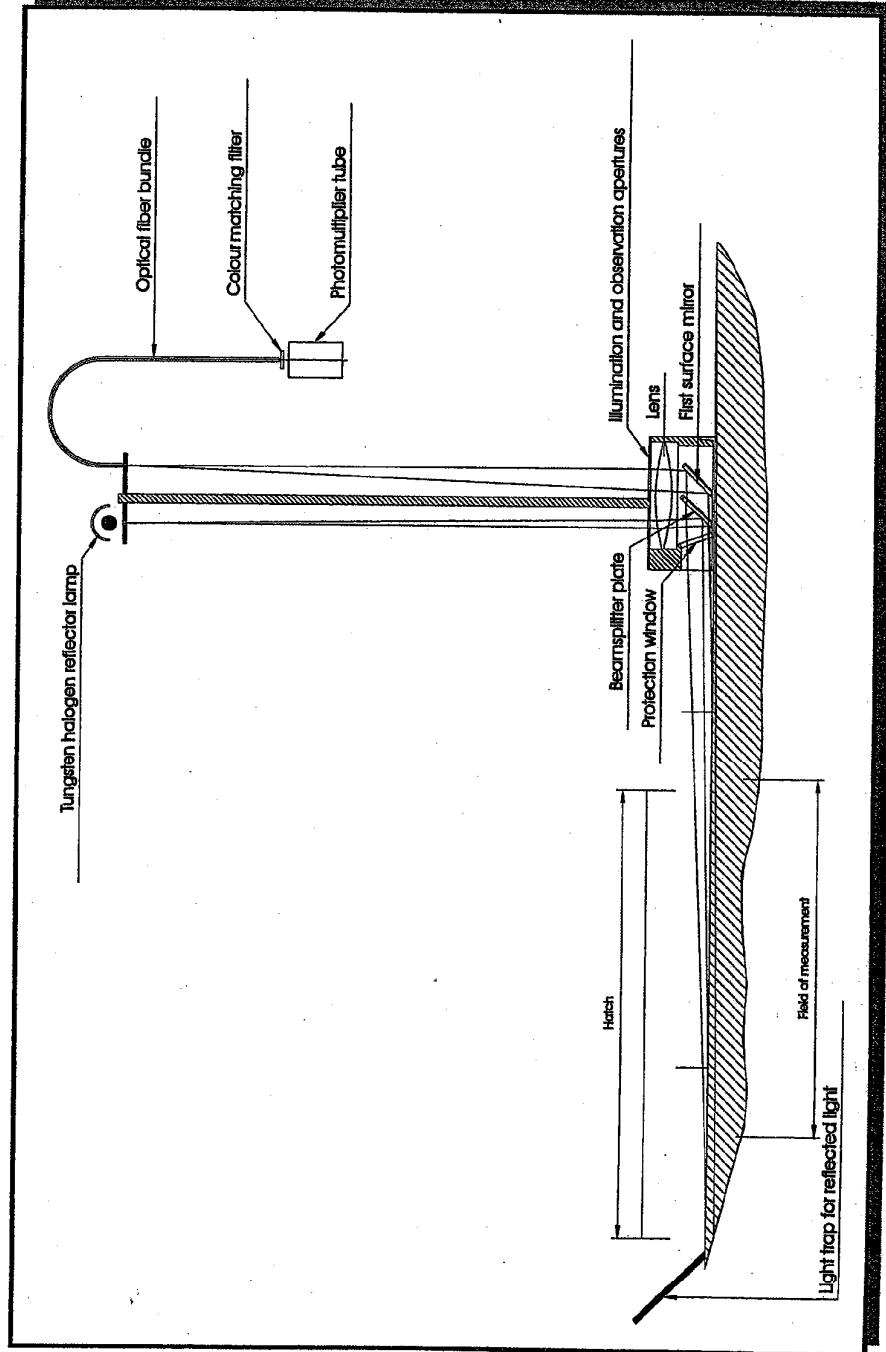


Figure 23 Principal Instrument Layout

Calibration Unit Placement Graphics.

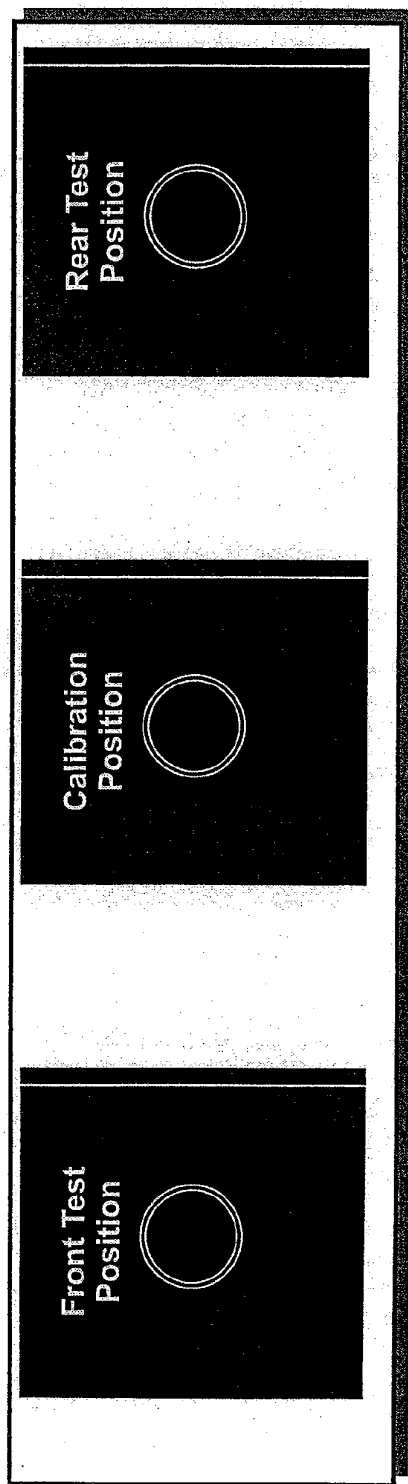


Figure 24 Graphics for placement of Calibration Unit

The graphics show the **Calibration Position** this is the correct position and orientation for the calibration unit to obtain optimal calibration precision. The **Rear Test Position** (near the tower) and the **Front Test Position** is used to verify that the instrument operates as specified over the entire measurement area.

LTL 2000

QUICK REFERENCE

SHEET

LTL 2000 Quick Reference Sheet

Ready the Instrument

- Turn on the LTL 2000
- Set Zero
- Calibrate
- Check the calibration
- Remove the LTL from the base frame
- Take Measurements

Calibration Block Safety

- Always store the calibration blocks in their specific holders when not in use
- Do not touch the white ceramic area of the calibration blocks
- Store the black calibration block in the office, it should never go into the field
- The black calibration block should never be cleaned

Turn on Instrument

- Press the **ON** button for 2 seconds

Zeroing Procedure

- Press **2'nd** and **Zero** button at the same time
- Press the **Enter** button
- Check that zero is **OK**
- Wait for ready status

Calibrating Procedure

- Press the **Calib.** button
- Press the **Enter** button
- Place the red calibration block into base frame
- Press the **Enter** button
- Make sure the number displayed matches the number on the red block
- Adjust the number to match the red block if necessary using the up & down arrow buttons
- Press the **Enter** button
- Wait for ready status

Take Readings

- Remove base frame by pulling latch slightly out until you pass the screw then lift up
- Slide entire unit forward & lift out of base frame
- Place base frame in case to minimize dust & dirt on base frame
- Place LTL on marking
- Press **RL** to take reading

ID Labels (create or change)

- Press the down arrow button with a regular reading on the screen
- Press the **Enter** button
- Press the up and down arrow buttons to get desired character (use the **2'nd** button and up or down arrow to scroll faster)
- Press the **Enter** button to move to the next space (go to previous step)
- Press the **Enter** button to finish (make sure you press the enter button until the last RL reading is displayed, or your ID will not be saved)

Print Readings

- Option 1 – to print individual reading
- Press the **Print** button to print last reading taken
- Option 2 – to print all readings in the data log
- Press the menu button until the display shows “Print RL Log”
- Press **Enter** to confirm printing
- Press **Enter** to start printing data log

Calibration Transfer

- Turn on LTL 2000
- Set Zero
- Calibrate on the Black Calibration Block
- Check the calibration
- Measure (RL) the Red Calibration Block
- Write the new RL value and date on the label of the Red Calibration Block

When to Calibrate

- Before the start of work each day at the place where you will take readings
- If the LTL 2000 has not been used for 30 minutes or more
- Once every 2 hours if the LTL is being used continuously all day

End of Day / Start of Day Check Out

- Check the base frame for any dust & dirt, clean with canned air or lint free cloth
- Check the optic window for any dust or dirt, clean with lint free cloth & windex
- Check that the calibration date on the Red field block is not more than 1 week old – if so, do a calibration transfer
- Make sure the battery is charged
- Make sure the data log has enough space

LTL 2000 Do's

- Make sure the operating temperature is 32F to +114F
- The humidity should be between 0 and 90% and non-condensing
- Make sure the markings are dry from application
- Make sure the markings and road are dry from water
- Make sure the unit acclimates to the environment for at least 15 minutes before use

LTL 2000 Don't's

- Use the instrument when moisture is condensing out of the air, such as early morning dew
- Use the instrument too soon after moving it place to place where the temperature or humidity are very different
- Take measurements on wet or damp markings
- Take the instrument from a cool or cold area to a warm or hot area without letting it acclimate to its surroundings

Primary Points

- When LTL is not in use return it to its case
- Do not take Black Block out into the field it should be kept in the office, this is your traceable calibration